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Field Sampling and Analysis for Performing a Remedial Investigation at Operable Unit 3: Off-Site Groundwater

National Aeronautics and Space Administration Jet Propulsion Laboratory

4800 Oak Grove Drive
Pasadena, California 91109

EBASCO ENVIRONMENTAL

MAY 1994

JET PROPULSION LABORATORY

INTEROFFICE MEMORANDUM

93-067.SF

May 26, 1994

TO: Distribution - Project Working Group

FROM: C. L. Buril

SUBJECT: Final Documents

A copy of the Final Field Sampling and Analysis Plan for OU-3 (FSAP-OU3) is enclosed for your information and files.

All previous copies of this document should be discarded.

If you have any questions regarding this submittal please contact me at x4-0180, or Judy Novelly at x4-8634.

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FINAL

FIELD SAMPLING AND ANALYSIS PLAN

FOR PERFORMING A REMEDIAL INVESTIGATION

AT

OPERABLE UNIT 3: OFF-SITE GROUNDWATER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JET PROPULSION LABORATORY
4800 OAK GROVE DRIVE
PASADENA, CALIFORNIA 91109

PREPARED BY

EBASCO ENVIRONMENTAL
3000 WEST MACARTHUR BLVD.
SANTA ANA, CALIFORNIA 92704

MAY 1994

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LIST OF ACRONYMS

CalTech	California Institute of Technology
CCL_4	Carbon Tetrachloride
CDHS	California Department of Health Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQA	California Environmental Quality Act
CLP	Contract Laboratory Program
DCA	Dichloroethane
DCE	Dichloroethene
DQOs	Data Quality Objectives
DWR	Department of Water Resources
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
FFA	Federal Facilities Agreement
FID	Flame-Ionization Detector
FPS	Feet Per Second
FS	Feasibility Study
FSAP	Field Sampling and Analysis Plan
GALCIT	Guggenheim Aeronautical Laboratory, California Institute of Technology
HASP	Health and Safety Plan
JPL	Jet Propulsion Laboratory
MCL	Maximum Contaminant Level
MP	Multi-Port
NASA	National Aeronautics and Space Administration
NDPM	NASA Designated Project Manager
NEPA	National Environmental Policy Act
NPL	National Priorities List
NTU	Nephelometric Turbidity Unit
OD	Outside Diameter
OSWER	Office of Solid Waste and Emergency Response
OUM	NASA Authorized Subcontractor Operable Unit Manager

LIST OF ACRONYMS

(Continued)

OU-1	Operable Unit 1
OU-2	Operable Unit 2
OU-3	Operable Unit 3
PCE	Tetrachloroethene (Perchloroethene)
PID	Photo-Ionization Detector
PSI	Pounds Per Square Inch
PVC	Poly Vinyl Chloride
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RWQCB	Regional Water Quality Control Board
SVOC	Semi-Volatile Organic Compound
TCA	1,1,1-Trichloroethane
TCE	Trichloroethene
TEGD	Technical Enforcement Guidance Document
TPH	Total Petroleum Hydrocarbons
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compound

1.0 INTRODUCTION

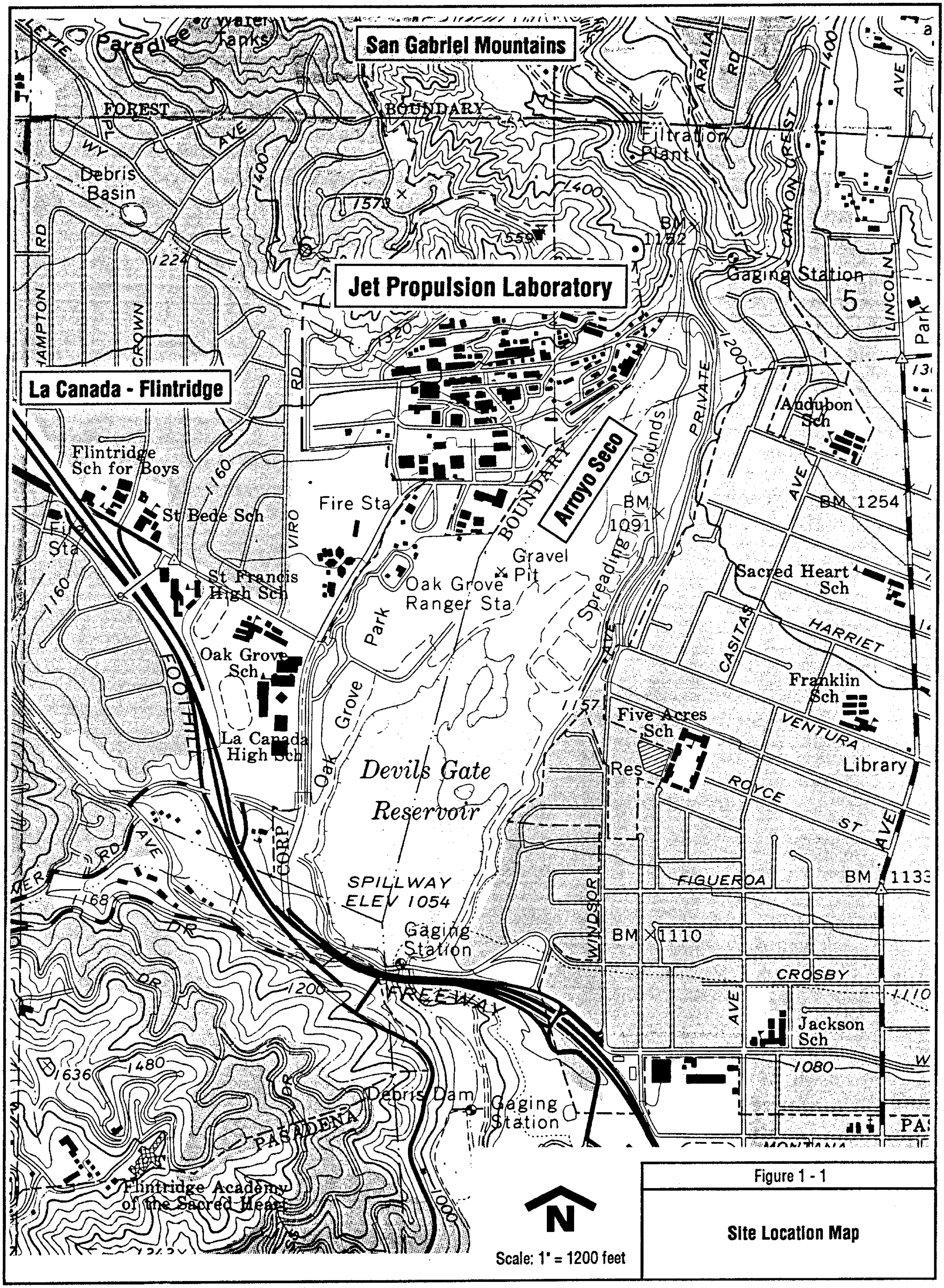
This Field Sampling and Analysis Plan (FSAP) is one of three documents used to describe the Remedial Investigation (RI) sampling and analysis program at the Jet Propulsion Laboratory (JPL) in Pasadena, California (Figure 1-1). The term "JPL" is used throughout this document to refer to the facilities located at 4800 Oak Grove Drive in Pasadena, California.

The National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory is currently subject to the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, since being placed on the National Priorities List (NPL) in October, 1992. This FSAP is the last of three to be produced, one each associated with the three operable units agreed upon by the United States Environmental Protection Agency (EPA), the California State Department of Toxic Substances Control (DTSC), the California Regional Water Quality Control Board (RWQCB), and NASA.

The activities presented in this FSAP will be executed in support of the Remedial Investigation (RI) of Operable Unit 3 (OU-3), the off-site groundwater operable unit. Operable Unit 1 (OU-1) is associated with the on-site groundwater characterization, and Operable Unit 2 (OU-2) pertains to the on-site contaminant source characterization. The boundary between on-site groundwater OU-1 and off-site groundwater OU-3 is illustrated on the site facility map in Figure 1-2.

This FSAP has been prepared using the EPA document "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (OSWER Directive 9355.3-01, Interim Final, October, 1988) and meets all applicable CERCLA, State of California and Federal Facility Agreement (FFA) requirements. This FSAP contains discussions of site background (Section 2.0), sampling objectives (Section 3.0), sample locations and frequency (Section 4.0), sample designation (Section 5.0), sampling equipment and procedures (Section 6.0), sample handling and analysis (Section 7.0), and references (Section 8.0).

A detailed description of the site background and the conceptual model that led to the development of the OU-3 FSAP is presented in the Remedial Investigation/Feasibility Study (RI/FS) Work Plan. In addition to this information, the RI/FS objectives are described along with the rationale for the proposed work. Other information presented in the Work Plan includes a description of RI/FS tasks, cost and key assumptions, schedule, and project management roles.



Scale: 1" = 1200 feet

Figure 1 - 1

Site Location Map

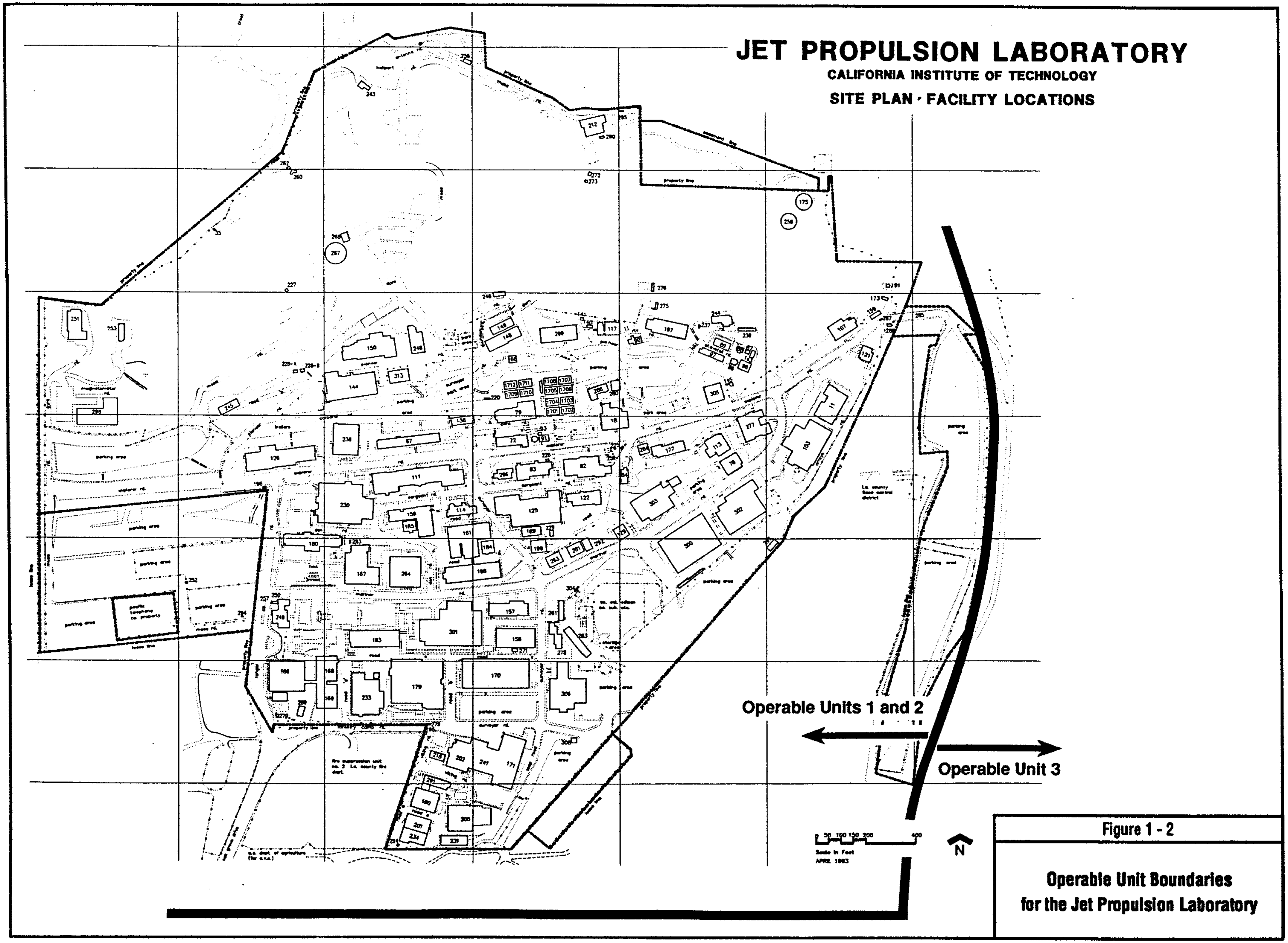


Figure 1 - 2

Operable Unit Boundaries for the Jet Propulsion Laboratory

The OU-3 proposed activities primarily involve off-site groundwater characterization at JPL. The characterization will focus on where potential contaminants occur, the vertical and horizontal extent of potential contaminants, and the configuration of the water table. Five deep multi-port monitoring wells with five screened intervals each have been proposed to achieve these objectives for the OU-3 RI.

2.0 SITE BACKGROUND

JPL is located within the cities of Pasadena and La Canada-Flintridge, California, northeast of the 210 Foothill Freeway. The site covers 176 acres and is situated at the base of the southern edge of the San Gabriel Mountains (Figure 1-1). The Arroyo Seco, an intermittent stream bed, lies immediately to the east and southeast of the site. Residential development borders the western boundary of the site.

JPL began in 1936 when Professor Theodore Von Karman of the California Institute of Technology (CalTech) and a group of students began testing liquid propellant rockets in the Arroyo Seco. At that time the work was being completed through CalTech's Guggenheim Aeronautical Laboratory (GALCIT). In 1940, the Army Air Corps provided funding and the first permanent structures were built near the present day site. By 1944, the site continued to grow and changed its name to the Jet Propulsion Laboratory, GALCIT. Ultimately, the site became known as the Jet Propulsion Laboratory, or JPL, and became a fully owned Federal facility. In 1958, NASA took control of JPL. Today, under a prime contract, CalTech performs research and development tasks at facilities provided by NASA and which are located at the present day site of JPL. CalTech also maintains the facilities as part of its contractual agreement with NASA.

For JPL to accomplish the research and development tasks under their purview, chemicals and materials with a variety of contaminant properties are, and have been utilized during the operational history of the site. The general types of materials used and produced, now and in the past, include a variety of solvents, solid and liquid rocket propellants, cooling-tower chemicals, and chemical laboratory wastes. During the 1940s and 1950s, many buildings at JPL maintained a cesspool to dispose of liquid and solid sanitary wastes collected from drains and sinks within that building. These cesspools were designed to allow liquid wastes to seep into the surrounding soil. Present-day terminology for these subsurface disposal areas is "seepage pits", which is used in this FSAP. Although the seepage pits were abandoned in the late 1950s and early 1960s when a sewer system was installed, some of the seepage pits may have received volatile organic compounds (VOCs). In 1980, analyses of groundwater from three City of Pasadena water-supply wells located near JPL indicated concentrations of trichloroethene (TCE), tetrachloroethene (PCE) and carbon tetrachloride (CCl_4) above drinking water standards.

Over the past 13 years a number of investigations focusing on geotechnical and environmental issues have been conducted at JPL. A detailed review of previous investigations at the site is presented in the RI Work Plan (Ebasco, 1993). In October 1992, JPL was included on the NPL and in December 1992 EPA, NASA, DTSC, and the RWQCB entered into a Federal Facilities Agreement (FFA) under CERCLA Section 120. The components of the field sampling program and the FSAP are designed to follow guidance set forth in the FFA.

To summarize the setting of the site, JPL is situated on a relatively steep alluvial slope at the southern edge of the San Gabriel Mountains and at the northern edge of the San Gabriel Valley. A series of east-west trending and north dipping thrust faults, referred to as the Sierra Madre Fault system, separate the mountains from the valley. Beneath JPL, the alluvial deposits range in thickness from 650 to 850 feet. The alluvial deposits rest on a crystalline basement complex made up of the same general rock types as those comprising the San Gabriel Mountains. The vadose zone ranges between 100 to 250 feet in thickness and the saturated alluvium forms a water-table aquifer ranging between 550 and 600 feet in thickness. The regional groundwater flow gradient is generally from JPL toward the southeast. However, the groundwater flow direction and gradient below JPL west of the Arroyo Seco has been shown to change due to precipitation and pumping events. Nearby City of Pasadena municipal water production wells and the Arroyo Seco spreading grounds, used for groundwater recharge, can have large influences on the local groundwater table.

3.0 SAMPLING OBJECTIVES

The overall goal of this sampling and analysis program is to contribute to the successful completion of the RI and provide the data needed to select a remedial alternative in the FS. To achieve these goals, the program outlined in this FSAP must effectively assess the nature and extent of contaminants related to JPL in the groundwater outside the JPL site boundaries and provide information on the nature of transport for any contaminant(s) identified. In addition, the possibility of contaminant migration onto the JPL site from some off-site source will be evaluated during this program. A number of objectives for this program have been developed that will assist in reaching these goals. The sampling objectives for OU-3 are the following:

- Identify the contaminants of concern associated with the JPL site.
- Delineate the vertical and horizontal extent of off-site groundwater contamination.
- Provide additional information on the possible location of as yet undiscovered source areas.
- Provide an expanded definition of the stratigraphy surrounding the site.
- Provide greater detail on the definition of the hydrologic setting by measuring the hydraulic head of groundwater for each screen within the multi-port wells.
- Locate and install wells to enhance off-site groundwater contaminant monitoring capability.

4.0 SAMPLE LOCATIONS AND FREQUENCY

Groundwater monitoring well locations have been chosen to determine the nature and extent of chemicals of interest in OU-3 groundwater. The proposed program will extend our understanding of groundwater conditions, satisfy program sampling objectives and facilitate collection of information necessary to further characterize existing contaminated media. If it is determined that the currently proposed wells do not meet the goals of the RI, additional wells will be installed. The rationale for selection of the current individual well locations is presented in Section 4.1. The frequency of sampling and the types of analyses required is presented in Section 4.2.

4.1 MONITORING WELL LOCATIONS

To understand the process through which the proposed monitoring well locations for OU-3 were determined, the known hydrogeology and groundwater contaminants on the JPL site (OU-1) were evaluated. The locations of existing and currently proposed monitoring wells for OU-1 are presented in Figure 4-1. A summary of location and construction details for the existing monitoring wells is presented in Table 4-1. The existing groundwater volatile-organic data and water-level data collected from periodic monitoring efforts of wells MW-1 through MW-7 since March 1990 are presented in Figures 4-2 through 4-7. A summary of the VOCs detected in the JPL monitoring wells is also presented in Table 4-2 and on Figure 4-8. The water-level data collected to date west of the Arroyo Seco indicates the groundwater gradient and flow directions can change because of influences from precipitation, the nearby City of Pasadena municipal production wells and the Arroyo Seco spreading grounds. As an example of changing directions of groundwater flow, groundwater elevation contour maps from four previous monitoring events are included in Figure 4-9. As also shown in Figure 4-9, the predominant groundwater flow directions can occasionally be reversed. The groundwater flow east of the Arroyo Seco may also change due to the above reasons, however, the extent, if any, of the change is currently not known.

Specific RI goals for the JPL operable units are summarized in Table 4-3. A description of each goal and the data collection methods to achieve them are also summarized. The final RI report for OU-3 will be a comprehensive document summarizing all findings and results obtained during the RIs for the three operable units. The proposed monitoring wells for OU-3 have been located based on existing analytical and water-level data and the RI goals. These wells would enhance the understanding of areas already under study in OU-1 and will allow for collection of data in areas where specific information is lacking. The installation of the new wells will also

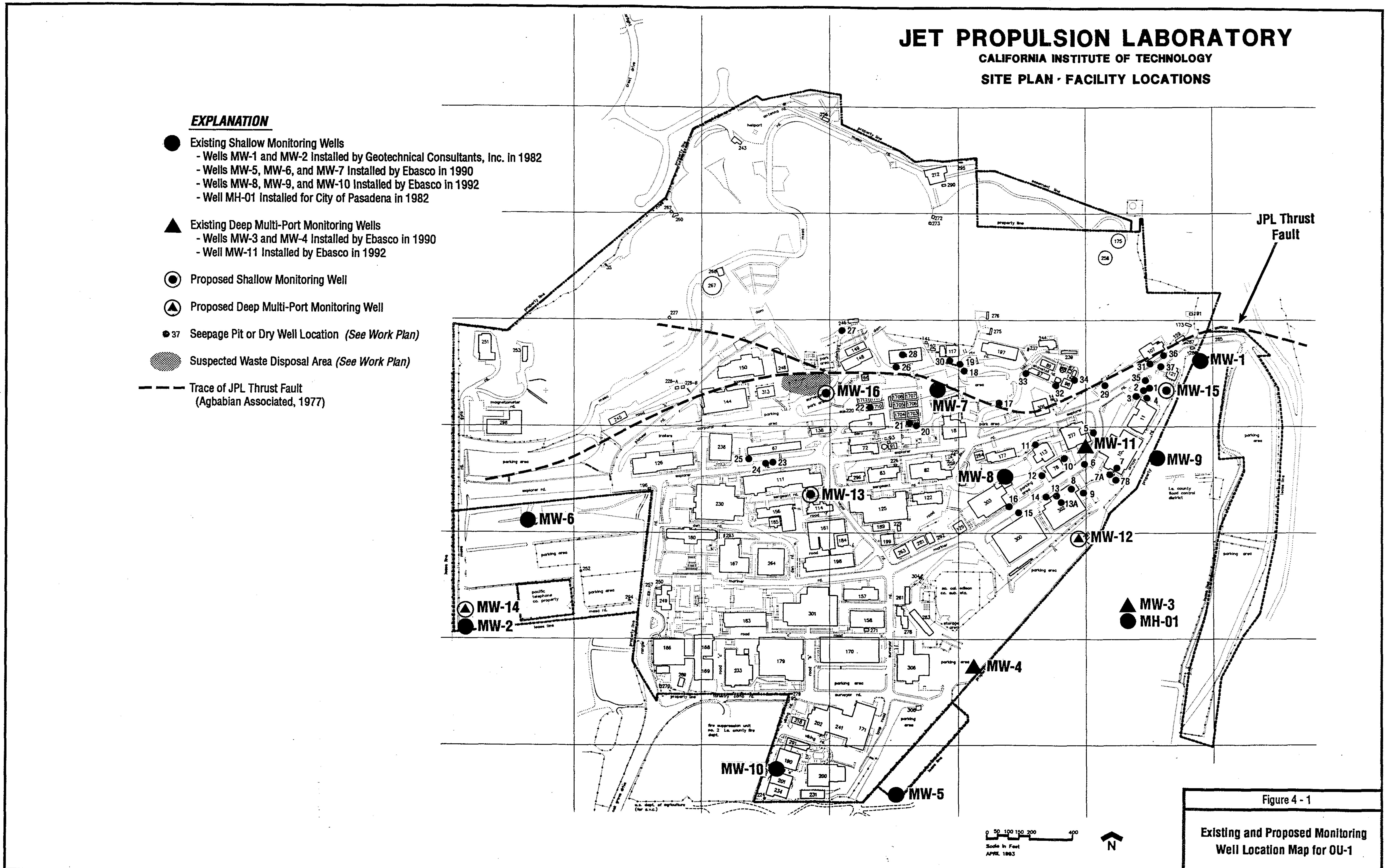


Figure 4 - 1

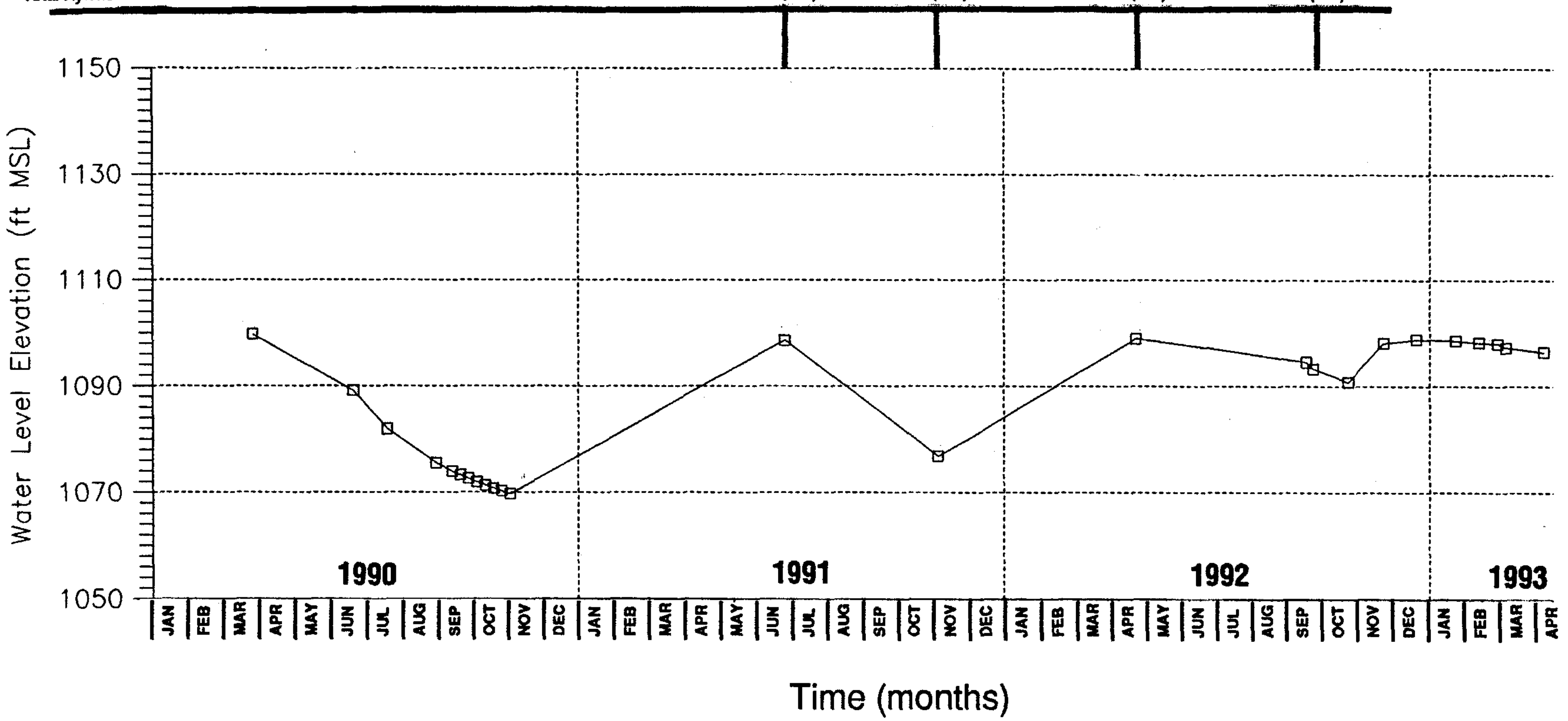
Existing and Proposed Monitoring Well Location Map for OU-1

Well MW-1

Sampling Date

Concentration in µg/l. Practical Quantitation Limit in Parenthesis

Parameter	6-91	11-91	4-92	9-92
Trichloroethene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*
Tetrachloroethene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*
Total Xylene	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*



ND: Not Detected

*: TCE (0.7 ug/l), PCE (0.6 ug/l), and Xylenes (0.6 ug/l) were detected but were also detected in the equipment blank.

Figure 4 - 2

Concentrations of VOCs Detected in Groundwater and Water Level Elevations in Monitoring Well MW-1

TABLE 4-1

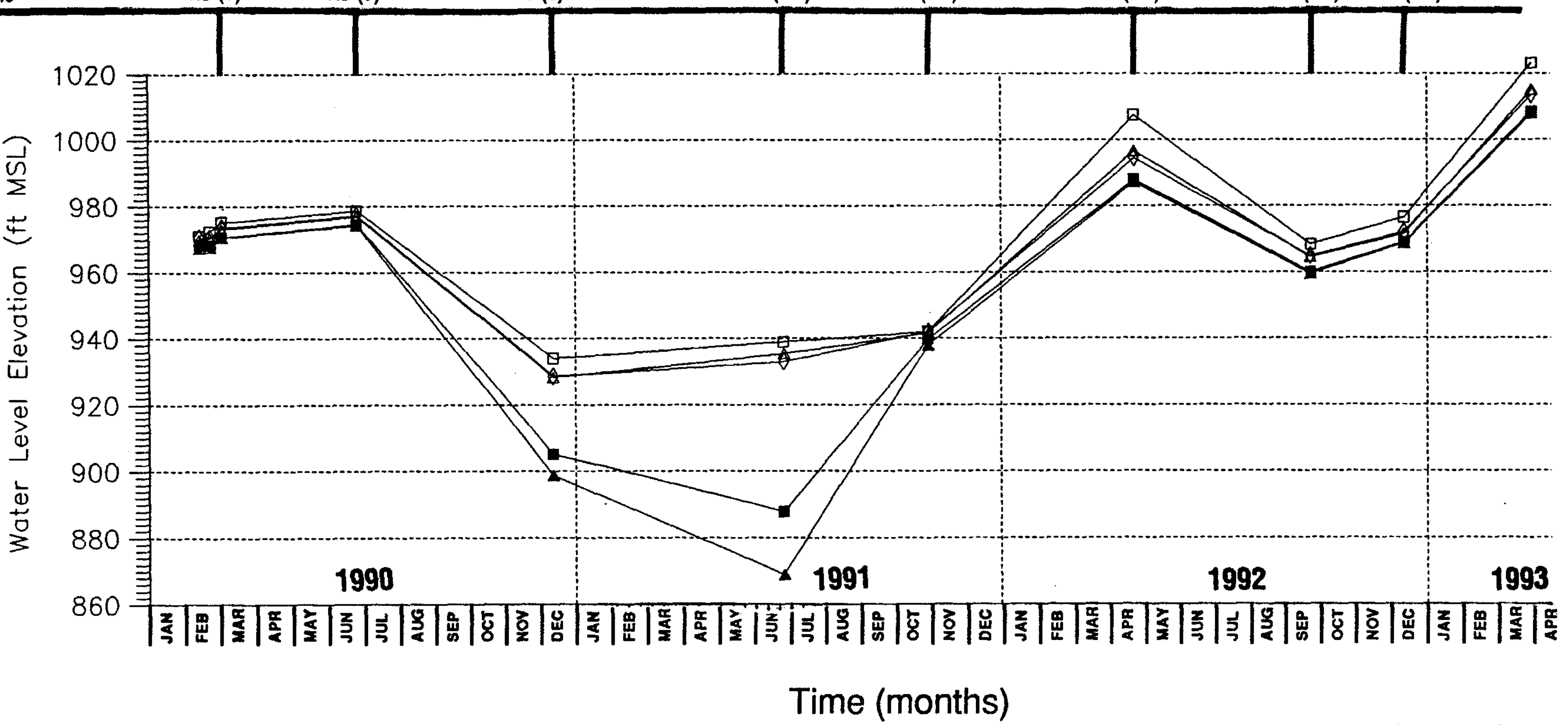
LOCATION AND CONSTRUCTION DETAILS FOR EXISTING MONITORING WELLS AT THE JET PROPULSION LABORATORY

Well Name	Well Location (UTM Zone 11)[1] Northing (meters)	Well Location (UTM Zone 11)[1] Easting (meters)	Top 4" Casing Elevation (feet above mean sea level)	4" Casing Total Depth (feet below ground surface)	Screened Interval (feet below ground surface)	Sampling Port Number	Sampling Port Depth (feet below ground surface)
MW-1	3,785,253.88	392,506.87	1117.05	120.0	70-110	---	---
MW-2[2]	3,784,875.00	391,450.00	1168.00	179.0	129-169	---	---
MW-3[3]	3,784,893.00	392,394.48	1100.26	700.2	170-180	1	172.0
					250-260	2	252.0
					344-354	3	346.0
					555-565	4	558.0
					650-660	5	653.0
MW-4[4]	3,784,814.98	392,170.24	1083.69	559.6	146.8-156.8	1	149.6
					237.2-247.2	2	239.6
					319.6-329.6	3	321.6
					388.9-398.9	4	391.6
					509.4-519.4	5	512.6
MW-5	3,784,637.09	392,063.66	1071.60	140	85-135	---	---
MW-6	3,785,031.48	391,541.01	1188.46	245	195-245	---	---
MW-7	3,785,211.05	392,128.27	1212.90	275	225-275	---	---
MW-8	3,785,086.61	392,220.27	1139.53	205	155-205	---	---
MW-9	3,785,113.00	392,441.66	1106.02	68	18-68	---	---
MW-10	3,784,670.25	391,893.96	1087.70	155	105-155	---	---
MW-11[5]	3,785,123.57	392,340.00	1139.31	680	140-150	1	149.4
					250-260	2	258.5
					420-430	3	428.8
					515-525	4	523.9
					630-640	5	639.1
MH-01[6]	3,784,685.04	392,474.98	1099.78	366	145-355	---	---

1: Universal Transverse Mercator (UTM) Coordinates based on North American Datum of 1983.
2: Coordinates approximate, scaled from map.
3: Depths measured from original ground surface.
4: Depths measured from current ground surface.
5: Depths measured from top 2-inch casing.
6: City of Pasadena monitoring well currently not sampled. Depths measured from top 6-inch casing. Well is screened in nine separate intervals between 145 and 355 feet.

Well MW-3

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	12-92
	Concentration in µg/l. Practical Quantitation Limit in Parenthesis							
Screen 1 Total Trihalomethanes[a]	7(5)	44(5)	13(5)	ND(0.5)	18(0.5)	ND (0.5)	ND (0.5)	7.8(0.5)
Screen 2 Carbon Tetrachloride	ND (5)	ND (5)	ND (5)	5.3(0.5)	2(0.5)	7.6(0.5)	7.6(0.5)	8.2(0.5)
Trichloroethene	ND (5)	ND (5)	13(5)	19(0.5)	20(0.5)	11(0.5)	11(0.5)	5.7(0.5)
Tetrachloroethene	ND (5)	ND (5)	ND (5)	1.2(0.5)	1.3(0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Trihalomethanes	6(5)	6(5)	6(5)	4(0.5)	6(0.5)	10(0.5)	10(0.5)	4.4(0.5)
Screen 3 Ethylbenzene	ND (5)	ND (5)	ND (5)	0.6(0.5)	0.5(0.5)	0.6(0.5)	0.6(0.5)	ND (0.5)
Styrene	ND (5)	ND (5)	ND (5)	0.9(0.5)	0.8(0.5)	0.7(0.5)	0.7(0.5)	ND (0.5)
Screen 4 No Detects	-	-	-	-	-	-	-	-
Screen 5 Carbon Disulfide	ND (5)	ND (5)	ND (5)	NA	NA	ND (1.25)	ND (1.25)	ND (0.5)
Styrene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)



ND: Not Detected
NA: Not Analyzed
a: Includes Chloroform, Bromoform, Dibromochloromethane, and Dichlorobromomethane

Figure 4 - 3

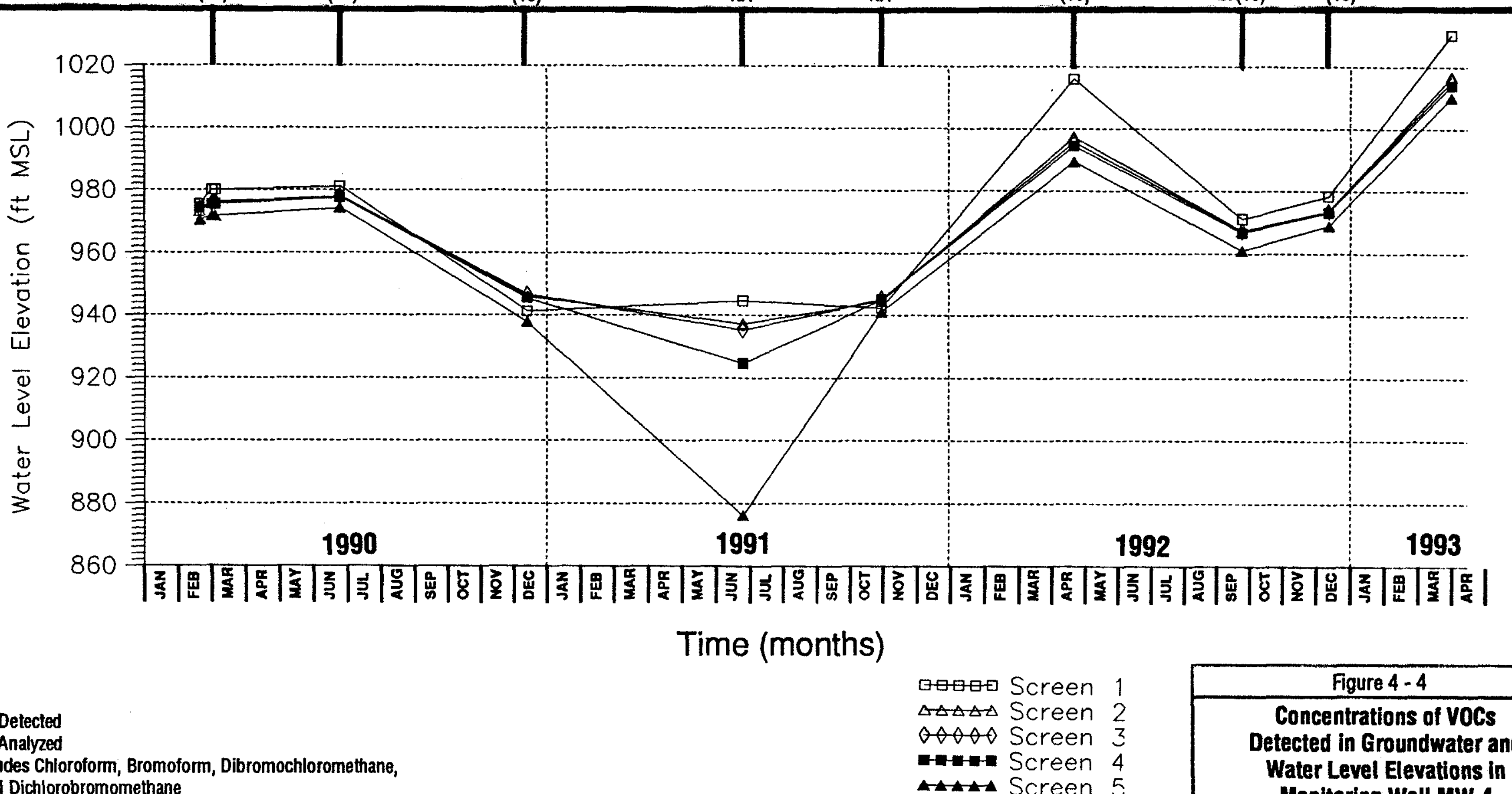
Concentrations of VOCs Detected in Groundwater and Water Level Elevations in Monitoring Well MW-3

Well MW-4

Sampling Date

Concentration in µg/l. Practical Quantitation Limit in Parenthesis

	Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	12-92
Screen 1	Trichloroethene	ND (5)	ND (5)	8(5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
	Total Trihalomethanes[a]	ND (5)	ND (5)	ND (5)	ND (0.5)	0.7(0.5)	ND (0.5)	ND (0.5)	ND (0.5)
	1,1,1-Trichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	5.2(0.5)	ND (0.5)	ND (0.5)
Screen 2	Trichloroethene	ND (5)	ND (5)	ND (5)	1.7(0.5)	0.9(0.5)	1.5(0.5)	1.7(0.5)	1.7(0.5)
	Total Trihalomethanes	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	0.5(0.5)	ND (0.5)
Screen 3	Trichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	2.3(0.5)	ND (0.5)	ND (0.5)
	Tetrachloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	2.6(0.5)	ND (0.5)	ND (0.5)
	1,1,1-Trichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	3.4(0.5)	ND (0.5)	ND (0.5)
	Toluene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	0.5(0.5)	ND (0.5)	ND (0.5)
Screen 4	No Detects	-	-	-	-	-	-	-	-
Screen 5	Acetone	-(10)	-(10)	-(10)	NA	NA	-(10)	25(10)	-(10)



ND: Not Detected
NA: Not Analyzed
a: Includes Chloroform, Bromoform, Dibromochloromethane, and Dichlorobromomethane

Figure 4 - 4

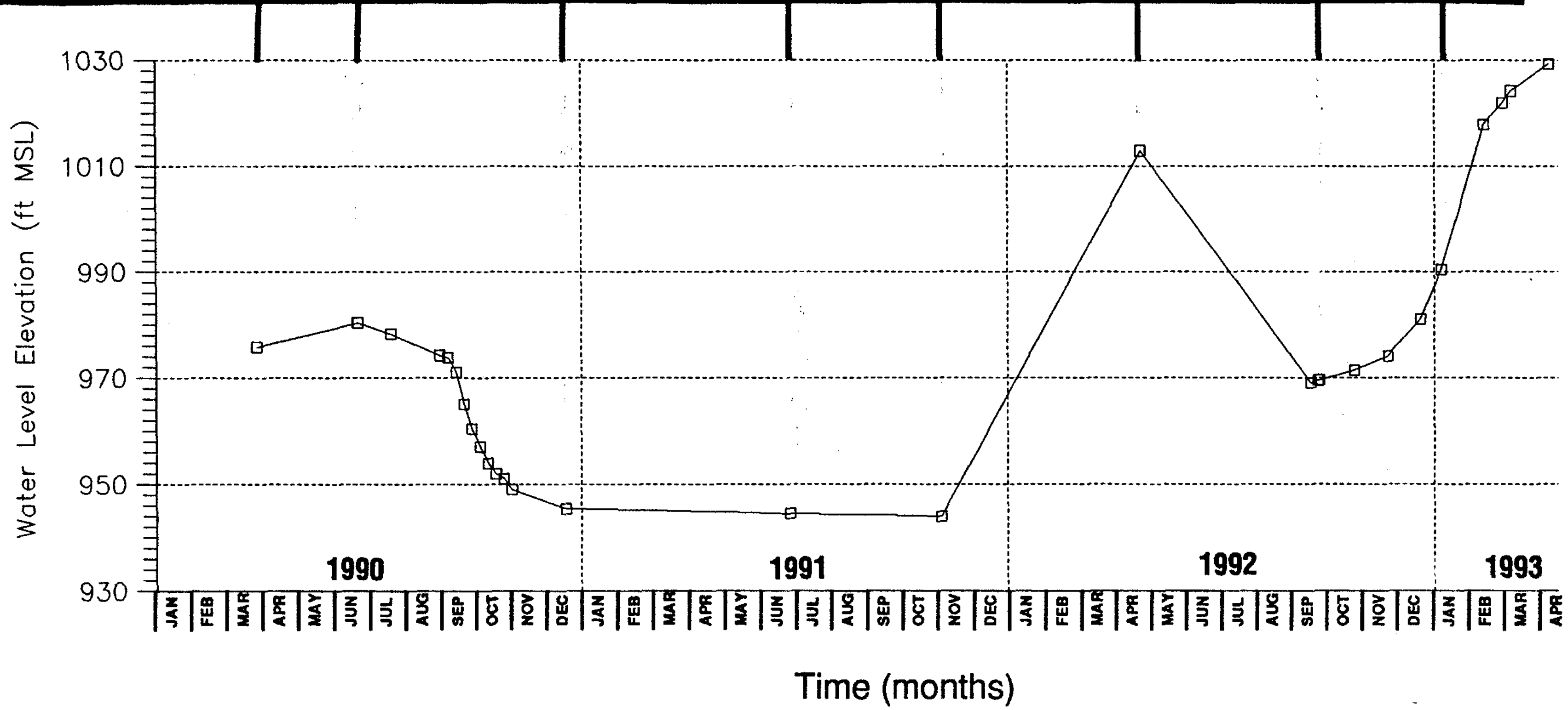
Concentrations of VOCs Detected in Groundwater and Water Level Elevations in Monitoring Well MW-4

Well MW-5

Sampling Date

Concentration in µg/l. Practical Quantitation Limit in Parenthesis

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	1-93
Carbon Tetrachloride	ND (5)	ND (5)	ND (5)	0.7(0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Trichloroethene	13(5)	ND (5)	86(5)	26(0.5)	16(0.5)	4.5(0.5)	1.0(0.5)*	ND (0.5)
Tetrachloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	0.6(0.5)	3.8(0.5)	0.8(0.5)*	ND (0.5)
1,1-Dichloroethane	ND (5)	ND (5)	ND (5)	ND (0.5)	0.8(0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Trihalomethanes	ND (5)	ND (5)	7(5)	2.4(0.5)	2.3(0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Toluene	ND (5)	6(5)	ND (5)	ND (0.5)	ND (0.5)	0.9(0.5)	ND (0.5)	ND (0.5)
cis-1,2-Dichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	5.4(0.5)	ND (0.5)	ND (0.5)
Total Xylenes	ND (5)	11(5)	ND (5)	ND (0.5)	ND (0.5)	1.3(0.5)	0.9(0.5)*	ND (0.5)



ND: Not Detected

*: Equipment Blank Results Indicate These VOC Values May Have Resulted From Trace Concentrations Remaining In The Purge Pump

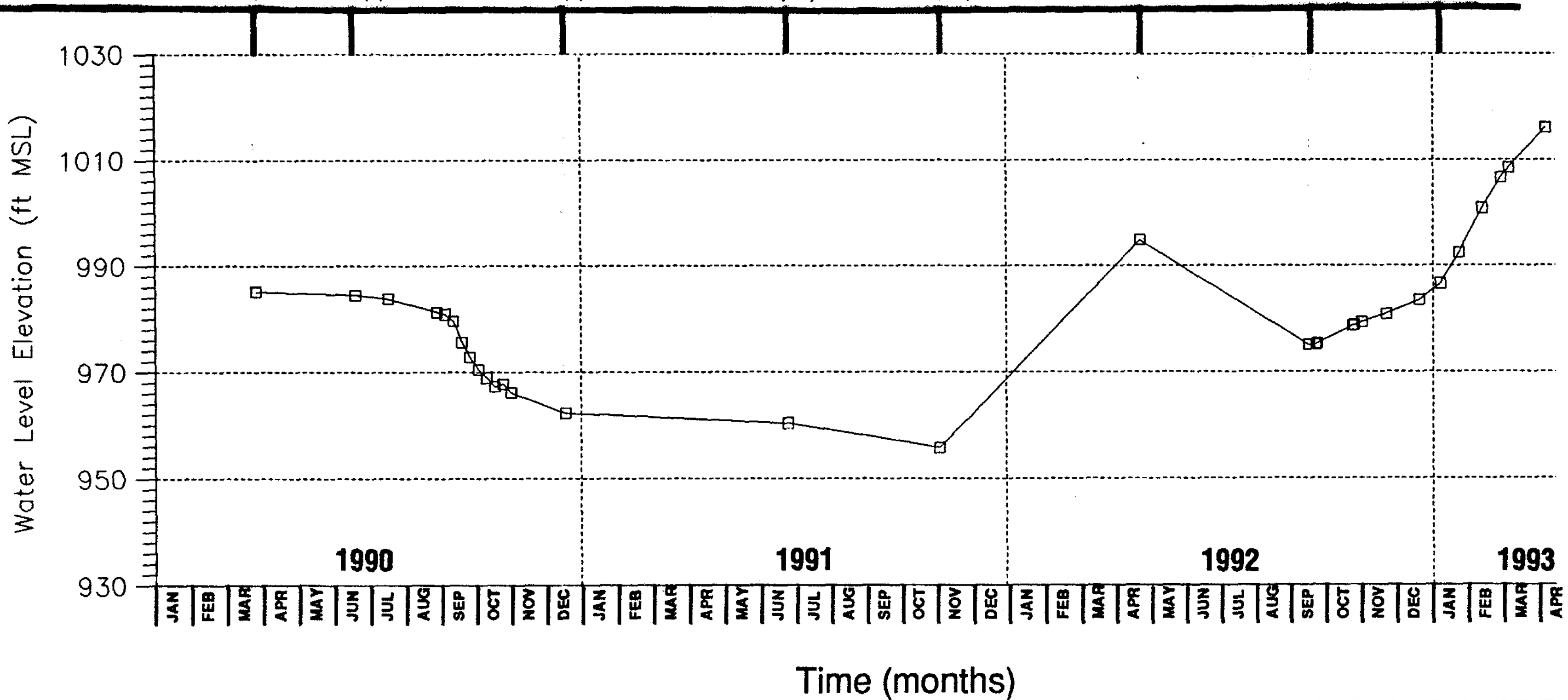
Figure 4 - 5

Concentrations of VOCs Detected in Groundwater and Water Level Elevations in Monitoring Well MW-5

Well MW-6

Sampling Date

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	1-93
	Concentration in µg/l. Practical Quantitation Limit in Parenthesis							
Trichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*	ND (0.5)
Tetrachloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*	0.5(0.5)
Total Trihalomethanes	30(5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Toluene	ND (5)	6(5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Xylenes	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)*	ND (0.5)



ND: Not Detected

*: TCE (0.8 ug/l), PCE (0.9 ug/l), and Xylenes (0.8 ug/l) were detected but were also detected in the equipment blank.

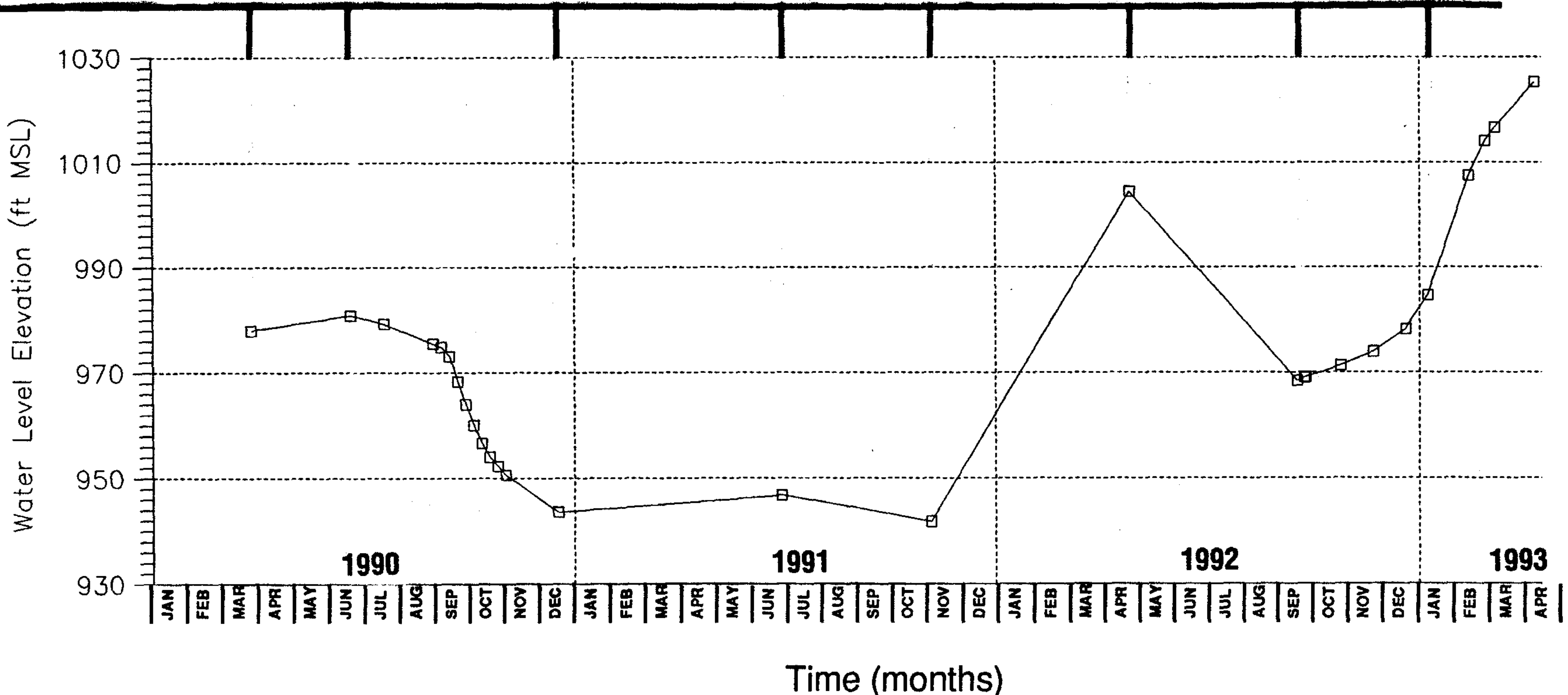
Figure 4 - 6

Concentrations of VOCs Detected in Groundwater and Water Level Elevations in Monitoring Well MW-6

Well MW-7

Sampling Date

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	1-93
	Concentration in $\mu g/l$. Practical Quantitation Limit in Parenthesis							
Carbon Tetrachloride	200(5)	200(5)	130(5)	190(0.5)	31(0.5)	260(0.5)	230(12.5)	120(10)
Trichloroethene	22(5)	27(5)	5(5)	7.5(0.5)	2(0.5)	30(0.5)	39(12.5	40(10)
Tetrachloroethene	15(5)	9(5)	28(5)	15(0.5)	5.5(0.5)	ND (25)	ND (12.5)	4.8(0.5)
1,1-Dichloroethane	8(5)	6(5)	14(5)	6.7(0.5)	3(0.5)	ND (25)	ND (12.5)	4.0(0.5)
1,2-Dichloroethene	ND (5)	ND (5)	ND (5)	ND (0.5)	ND (0.5)	ND (25)	ND (12.5)	9.0(0.5)
Total Trihalomethanes	23(5)	19(5)	15(5)	14(0.5)	5.4(0.5)	ND (25)	19(12.5)	17(10)
Toluene	ND (5)	5(5)	ND (5)	ND (0.5)	ND (0.5)	ND (25)	ND (12.5)	ND (0.5)
Freon 113	NA	NA	ND (5)	ND (0.5)	ND (0.5)	NA	NA	9.0(0.5)



ND: Not Detected
NA: Not Analyzed

Figure 4 - 7

Concentrations of VOCs Detected in Groundwater and Water Level Elevations in Monitoring Well MW-7

TABLE 4-2

VOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER SAMPLES COLLECTED FROM JPL MONITORING WELLS

(Concentrations in $\mu g/l$ Practical Quantitation Limits in Parentheses)

Parameter	Sampling Date								Regulatory Threshold[b]
	3-90	6-90	12-90	6-91	11-91	4-92	9-92	12-92, 1-93	
WELL MW-1									
Trichloroethene (TCE)	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	0.7(0.5)*	Not Sampled	5
Tetrachloroethene (PCE)	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	0.6(0.5)*	(no access)	5
Total Xylenes	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	0.6(0.5)*		1750
WELL MW-3									
SCREEN 1 (Top)									
Total Trihalomethanes[a]	7(5)	44(5)	13(5)	–(0.5)	18(0.5)	–(0.5)	–(0.5)	7.8(0.5)	100
SCREEN 2									
Carbon Tetrachloride	–(5)	–(5)	–(5)	5.3(0.5)	2(0.5)	7.6(0.5)	2.3(0.5)	8.2(0.5)	0.5
Trichloroethene (TCE)	–(5)	–(5)	13(5)	19.(0.5)	20(0.5)	11(0.5)	2.1(0.5)	5.7(0.5)	5
Tetrachloroethene (PCE)	–(5)	–(5)	–(5)	1.2(0.5)	1.3(0.5)	-(0.5)	–(0.5)	–(0.5)	5
Total Trihalomethanes[a]	6(5)	6(5)	6(5)	4(0.5)	6(0.5)	10(0.5)	3.7(0.5)	4.5(0.5)	100
SCREEN 3									
Ethylbenzene	–(5)	–(5)	–(5)	0.6(0.5)	0.5(0.5)	0.6(0.5)	0.8(0.5)	–(0.5)	680
Styrene	–(5)	–(5)	–(5)	0.9(0.5)	0.8(0.5)	0.7(0.5)	0.8(0.5)	–(0.5)	unregulated
SCREEN 4									
No Detects									
SCREEN 5 (Bottom)									
Carbon Disulfide	–(5)	–(5)	–(5)	NA	NA	–(1.25)	0.6(0.5)	–(0.5)	unregulated
Styrene	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	0.5(0.5)	–(0.5)	unregulated
WELL MW-4									
SCREEN 1 (Top)									
Trichloroethene (TCE)	–(5)	–(5)	8(5)	–(0.5)	–(0.5)	–(0.5)	–(0.5)	–(0.5)	5
Total Trihalomethanes[a]	–(5)	–(5)	–(5)	–(0.5)	0.7(0.5)	–(0.5)	–(0.5)	–(0.5)	100
1,1,1-Trichloroethane	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	5.2(0.5)	–(0.5)	–(0.5)	200
SCREEN 2									
Tetrachloroethene (TCE)	–(5)	–(5)	–(5)	1.7(0.5)	0.9(0.5)	1.5(0.5)	1.7(0.5)	1.7(0.5)	5
Total Trihalomethanes[a]	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	0.5(0.5)	–(0.5)	100

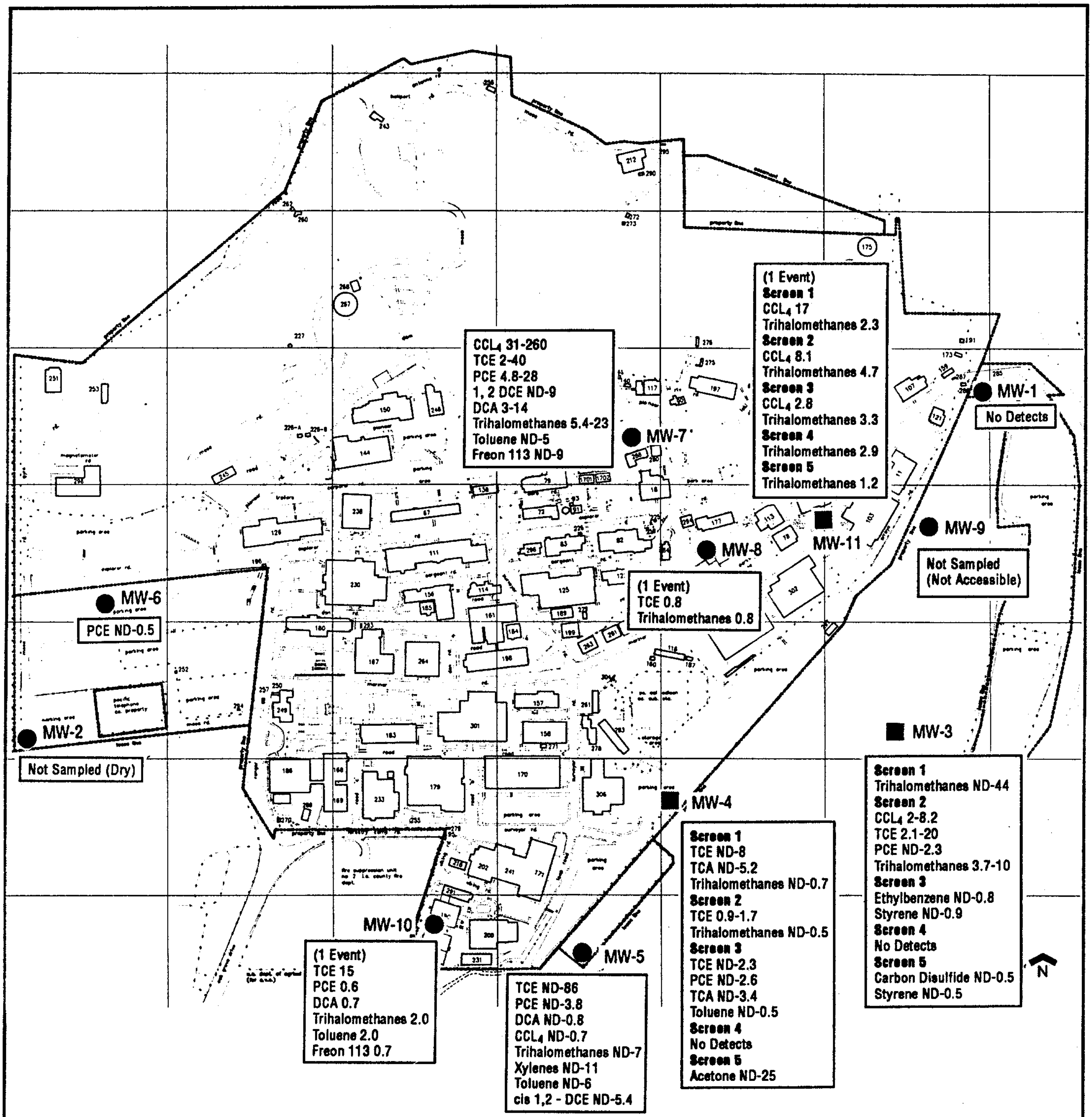
TABLE
(Continued)

Parameter	Sampling Date 3-90	6-90	12-90	6-91	11-91	4-92	9-92	12-92, 1-93	Regulatory Threshold[b]
SCREEN 3									
Trichloroethene (TCE)	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	2.3(0.5)	–(0.5)	–(0.5)	5
Tetrachloroethene (PCE)	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	2.6(0.5)	–(0.5)	–(0.5)	5
1,1,1-Trichloroethane	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	3.4(0.5)	–(0.5)	–(0.5)	200
Toluene	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	0.5(0.5)	–(0.5)	–(0.5)	100
SCREEN 4									
No Detects									
SCREEN 5 (Bottom)									
Acetone	–(10)	–(10)	–(10)	NA	NA	–(10)	25(10)	–(10)	100[c]
WELL MW-5									
Carbon Tetrachloride	–(5)	–(5)	–(5)	0.7(0.5)	–(0.5)	–(0.5)	–(0.5)	–(0.5)	0.5
Trichloroethene (TCE)	13(5)	–(5)	86(5)	26(0.5)	16(0.5)	4.5(0.5)	1.0(0.5)*	–(0.5)	5
Tetrachloroethene (PCE)	–(5)	–(5)	–(5)	–(0.5)	0.6(0.5)	3.8(0.5)	0.8(0.5)*	–(0.5)	5
1,1-Dichloroethane	–(5)	–(5)	–(5)	–(0.5)	0.8(0.5)	–(0.5)	–(0.5)	–(0.5)	5
Total Trihalomethanes[a]	–(5)	–(5)	7(5)	2.4(0.5)	2.3(0.5)	–(0.5)	–(0.5)	–(0.5)	100
Toluene	–(5)	6(5)	–(5)	–(0.5)	–(0.5)	-0.9(0.5)	–(0.5)	–(0.5)	100
cis-1,2-Dichlorenthene	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	5.4(0.5)	–(0.5)	–(0.5)	6
Total Xylenes	–(5)	11(5)	–(5)	–(0.5)	–(0.5)	1.3(0.5)	0.9(0.5)*	–(0.5)	1750
WELL MW-6									
Trichloroethene (TCE)	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	0.8(0.5)*	–(0.5)	5
Tetrachloroethene (PCE)	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	0.9(0.5)*	0.5(0.5)	5
Total Trihalomethanes[a]	30(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	–(0.5)	–(0.5)	100
Toluene	–(5)	6(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	–(0.5)	–(0.5)	100
Total Xylenes	–(5)	–(5)	–(5)	–(0.5)	–(0.5)	–(0.5)	0.8(0.5)*	–(0.5)	1750
WELL MW-7									
Carbon Tetrachloride	200(5)	200(5)	130(5)	190(0.5)	31(0.5)	260(25)	230(12.5)	120(10)	0.5
Trichloroethene (TCE)	22(5)	27(5)	5(5)	7.5(0.5)	2(0.5)	30(25)	39(12.5)	40(10)	5
Tetrachloroethene (PCE)	15(5)	9(5)	28(5)	15(0.5)	5.5(0.5)	–(25)	–(12.5)	4.8(0.5)	5
1,1-Dichloroethene	8(5)	6(5)	14(5)	6.7(0.5)	3(0.5)	–(25)	–(12.5)	4.0(0.5)	6
1,2-Dichloroethane	–(5)	–(5)	–(5)	–(5)	–(5)	–(25)	–(12.5)	9.0(0.5)	5
Total Trihalomethanes[a]	23(5)	19(5)	15(5)	14(5)	5.4(0.5)	–(25)	19(12.5)	17(10)	100
Toluene	–(5)	5(5)	–(5)	–(0.5)	–(0.5)	–(25)	–(12.5)	–(0.5)	100
Freon 113	NA	NA	NA	NA	NA	NA	NA	9.0(0.5)	1200

TABLE 4
(Continued)

Parameter	3-90	6-90	12-90	6-91	11-91	4-92	9-92	12-92, 1-93	Regulatory Threshold[b]
	Sampling Date								
WELL MW-8									
Trichloroethene (TCE)				Well Installed in December 1992				0.8(0.5)	5
Total Trihalomethanes[a]								0.8(0.5)	100
WELL MW-9									
Not Sampled (Access road washed out)				Well Installed in December 1992					
WELL MW-10									
Trichloroethene (TCE)								15(1)	5
Tetrachloroethene (PCE)				Well Installed in December 1992				0.6(0.5)	5
1,1-Dichloroethane								0.7(0.5)	6
Total Trihalomethanes[a]								2.0(0.5)	100
Toluene								0.7(0.5)	100
Freon 113								2(0.5)	1200
WELL MW-11									
SCREEN 1 (Top)									
Carbon Tetrachloride								17(0.5)	0.5
Total Trihalomethanes[a]								2.3(0.5)	100
SCREEN 2									
Carbon Tetrachloride								8.1(0.5)	0.5
Total Trihalomethanes[a]				Well Installed in December 1992				4.7(0.5)	100
SCREEN 3									
Carbon Tetrachloride								2.8(0.5)	0.5
Total Trihalomethanes[a]								3.3(0.5)	100
SCREEN 4									
Total Trihalomethanes[a]								2.9(0.5)	100
SCREEN 5 (Bottom)									
Total Trihalomethanes[a]								1.2(0.5)	100

*: Equipment blank results indicate these VOC values may have resulted from trace concentrations remaining in the purge pump.
–: Not Detected.
NA: Not Analyzed.
a: Includes chloroform, bromoform, dibromochloromethane, and dichlorobromomethane.
b: California Administration Code, Title 22 Maximum Contaminant Levels for Drinking Water.
c: Non-enforceable health based guidance number.



LEGEND

● Shallow Monitoring Wells

■ Deep Multi-Port Monitoring Wells

TCE ND-1 PCE ND-7	Ranges of Concentrations (ug/L) of Detected Volatile Organic Compounds

CCL_4 = Carbon Tetrachloride

TCE = Trichloroethene

PCE = Tetrachloroethene

TCA = 1, 1, 1 - Trichloroethane

DCE = 1, 1 - Dichloroethene

DCA = 1, 1 - Dichloroethane

Figure 4 - 8

Summary of Ranges of Volatile Organic Compounds Detected in the Groundwater at the Jet Propulsion Laboratory

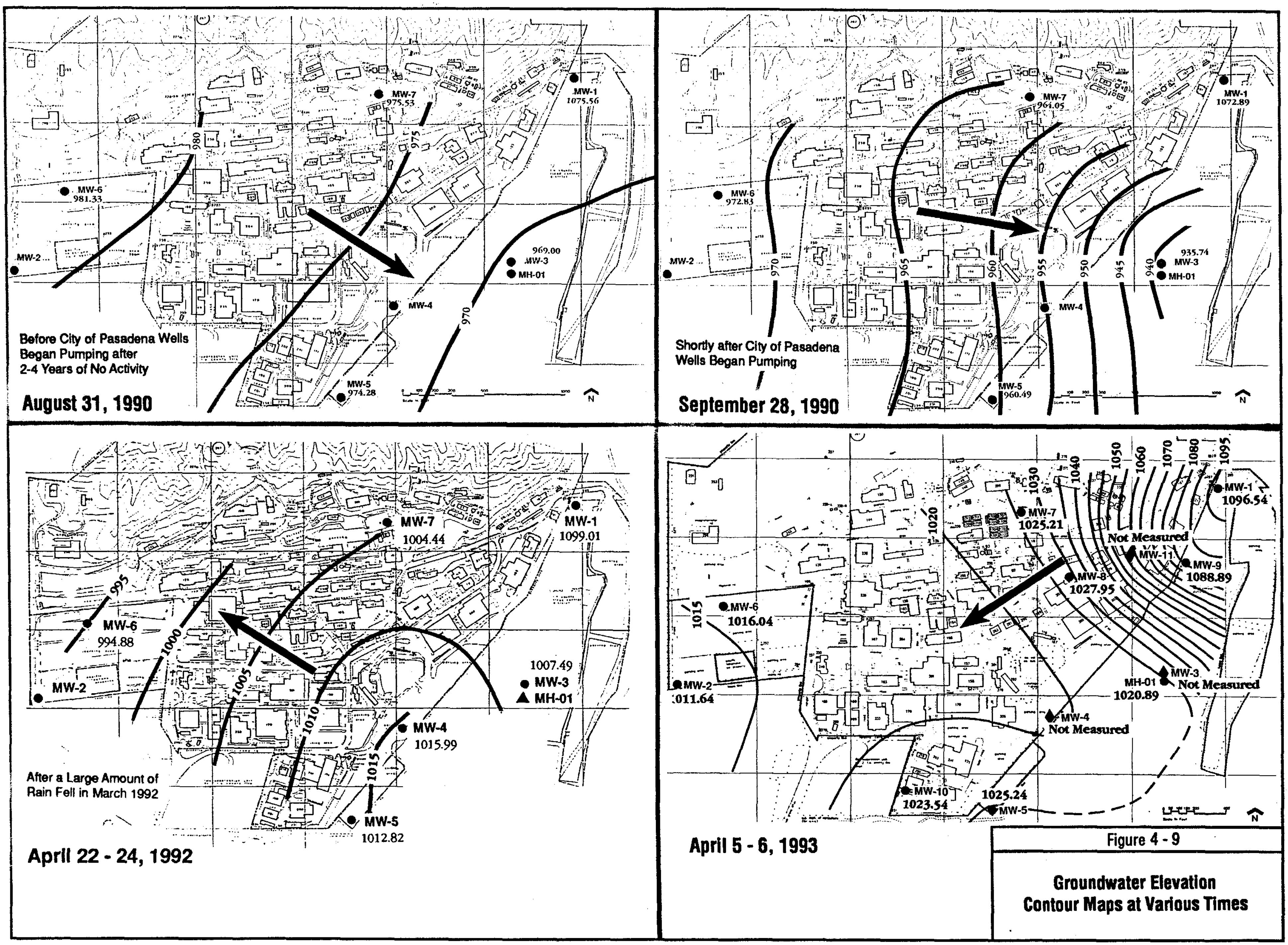


Figure 4 - 9

Groundwater Elevation Contour Maps at Various Times

TABLE 4-3

SUMMARY OF RI GOALS FOR OPERABLE UNITS

Topic	Goal	Proposed Data Collection	Operable Unit
Hydrologic Boundaries	Identify hydrologic divides, if present, and their impact on contaminant transport.	Install additional wells and collect area-wide water level measurements.	OU-1/OU-3
Hydrologic Parameters	Determine aquifer hydraulic conductivities, flow rates, etc.	Perform aquifer tests in monitoring wells.	OU-1/OU-3[1]
Water Budget	Determine influence of pumping centers, precipitation, and spreading grounds on aquifer and fate and transport of contaminants (needed for FS).	Monitor basin change in storage and chemical signatures when all RI wells are installed. Monitor operational periods and pumping rates of production wells as well as precipitation and spreading ground data.	OU-1/OU-3
Basin Projected Use	Assess impacts of future planned activities on fate and transport and on potential remedial alternatives.	Monitor and have input to basin planning and NEPA/CEQA process.	All
Constituents of Interest	Identify groundwater contaminants beneath JPL and east of the Arroyo Seco.	Drill, install and monitor on-site and off-site wells. Routinely sample for contaminants.	OU-1/OU-3
Fate and Transport	Identify nature and extent of vadose zone contaminants.	Drill, install and monitor on-site soil vapor probes and sample for contaminants and other parameters.	OU-2
	Identify nature and extent of groundwater contaminants and estimate transport rates.	Drill, install and monitor on-site and off-site wells. Sample for contaminants and other parameters.	OU-1/OU-3
	Determinine continued influence of contaminant sources on groundwater contaminant concentrations.	As above.	OU-1/OU-3
Geology and Stratigraphy	Evaluate geologic controls on groundwater flow.	Assimilate geologic data obtained from soil borings, wells installed during RI, and off-site well logs.	All
Surface Water Infiltration	Evaluate influence of surface water infiltration on contaminant concentrations and potential remediated groundwater volumes.	Collect and evaluate precipitation, stream gaging station and groundwater table elevation data.	All

Notes:

1: OU-3 multi-port wells monitored for hydraulic head only.

further enhance the groundwater quality monitoring capability off the JPL site by providing well coverage in strategic site locations to monitor the vertical and lateral extent of potential contaminants of interest as they are affected by potential changes in groundwater flow directions. During the RI, groundwater samples deemed to represent background conditions will be assessed on the basis of the groundwater flow directions present during the sampling events.

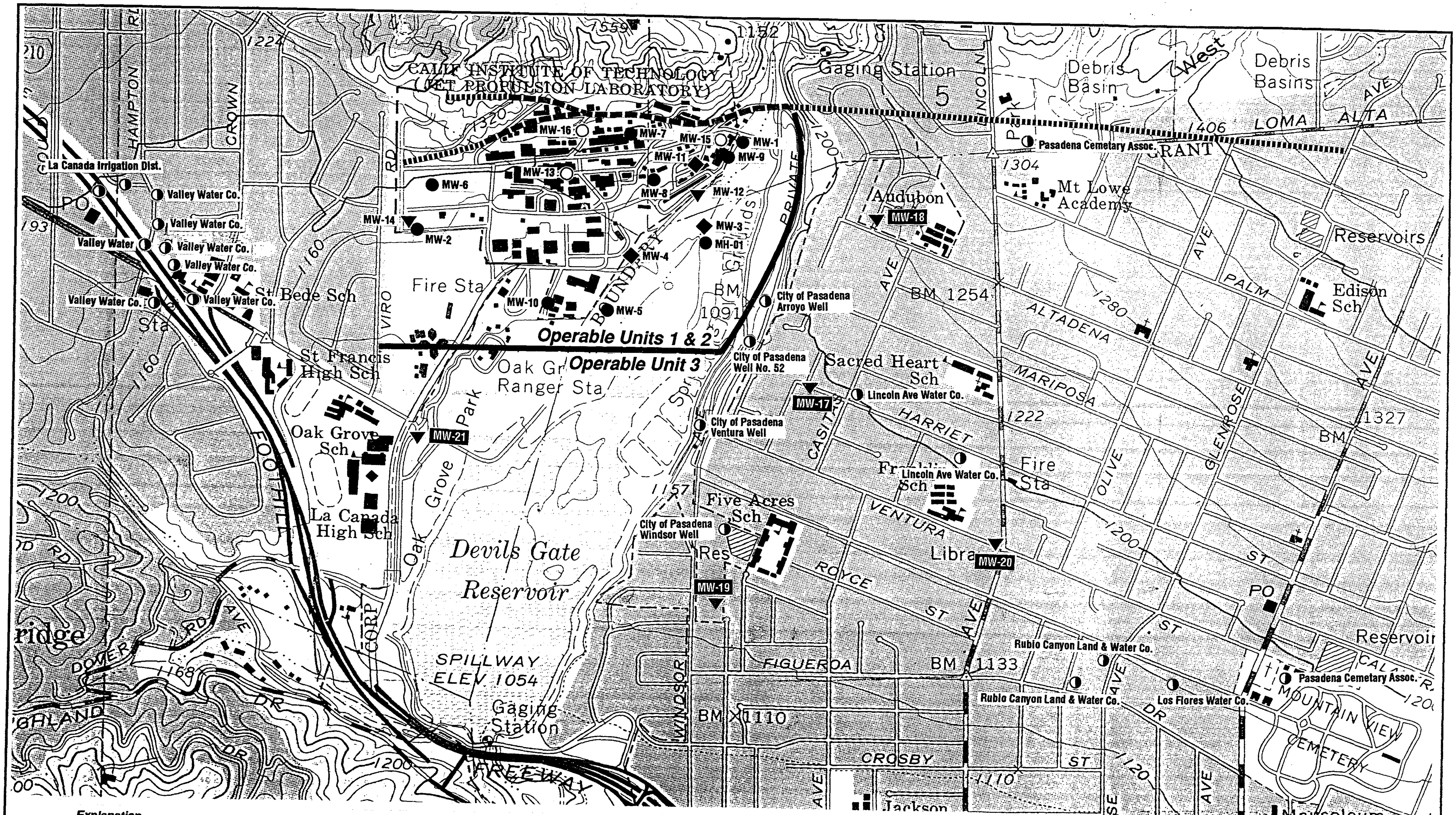
The OU-3 groundwater component of the RI focuses on determining where contaminants may occur, the vertical and horizontal extent of such contaminants, and the configuration of the water table. It is planned that the OU-3 wells will be drilled to the crystalline basement rock and will range in depth from approximately 500 feet to 925 feet. The geographic locations for the proposed wells are presented in Figure 4-10, and construction details are discussed in Section 6.1.2.2. Four proposed multi-port wells (MW-17, MW-18, MW-19, and MW-20) are located to the east and south of the JPL site where specific hydrogeologic information is lacking. Proposed multi-port well MW-21 will assist in characterizing upgradient conditions to the west of JPL and municipal supply wells.

The rationale for selecting each proposed OU-3 monitoring well location is summarized below.

Rationale for the Locations of Off-Site Monitoring Wells

The depths of all proposed monitoring wells have been estimated on the basis of an isopach map illustrating the approximate thickness of sediments in the vicinity of the JPL site produced by the California Department of Conservation (Division of Mines and Geology, Geology of the North Half of the Pasadena Quadrangle, Los Angeles County, California, 1986).

- Well MW- 17, a proposed 725- to 750-foot-deep multi-port monitoring well, will be located approximately midway between the City of Pasadena and Lincoln Avenue municipal supply wells. It will be located approximately 700 feet east of the Arroyo Seco Spreading Grounds and 2,200 feet southeast of JPL (Figure 4-10). Well MW-17 will be used to monitor potential contaminant migration both horizontally and vertically downgradient of JPL in the vicinity of the City of Pasadena municipal supply wells. As a deep multi-port completion, MW-17 will provide information on the potential vertical contaminant distribution that cannot be obtained from the municipal supply wells because of the extremely long screen intervals of the municipal supply wells. In addition, MW-17 will be used to measure potentiometric-surfaces that will be used to help evaluate the groundwater system in the vicinity of the nearby municipal supply wells.
- Well MW-18, a proposed deep multi-port monitoring well, will be approximately 825 feet deep and located approximately 1,300 feet east of JPL (Figure 4-10). When completed, MW-18 will be used to monitor potential contaminant movement downgradient from the JPL site. As a deep multi-port completion, the well will also provide information on the potential vertical contaminant distribution. MW-18 will



Explanation

- Existing Shallow Monitoring Well
- Proposed Shallow Monitoring Well
- Existing Deep Multi-Port Monitoring Well
- Proposed Deep Multi-Port Monitoring Well
- Municipal Wells
- Trace of JPL Thrust Fault
- Inferred JPL Thrust Fault *{Ref.: Section of Inferred Fault East of JPL from OFR-4 LA, Geology of North Half of the Pasadena Quadrangle, Los Angeles County, CA 1986}*
- Operable Unit Boundary

N

Drawing References: OFR 86-4 LA, Raymond Basin Watermaster Report (1988-1989)
USGS 7.5 Minute Pasadena Quadrangle

Figure 4 - 10

Existing and Proposed Monitoring & Supply Well Location Map

also be used for potentiometric-surface surveys that will be used to help evaluate the groundwater system off the site. On the basis of information obtained from MW-18 and Operable Unit 1 monitoring wells, it will be established if an additional well(s) is needed.

- Well MW-19, a proposed multi-port monitoring well will be drilled to an estimated depth of 680 feet and will be located approximately 4,000 feet southeast of JPL (FIgure 4-10). When completed, MW-19 will be used to evaluate potential contaminant migration toward the Los Flores Water Company municipal supply wells downgradient of the JPL site. As a deep multi-port completion, the well will provide information on the potential vertical contaminant distribution. Well MW-19 will also be used for potentiometric-surface surveys that will be used to define the groundwater system between the City of Pasadena wells and Los Flores Water Company wells.
- Well MW-20, a proposed deep multi-port monitoring well estimated to be at least 925 feet deep, will be located approximately 3,000 feet east from the Arroyo Seco Spreading Grounds (Figure 4-10). When completed, MW-20 will be used to monitor potential contaminant movement downgradient from the JPL site. As a deep multi-port completion, the well will also provide information on the potential vertical contaminant distribution. MW-20 will also be used for potentiometric-surface surveys that will be used to help evaluate the groundwater system in the vicinity of municipal production wells.
- Well MW-21, a proposed 500-foot-deep multi-port monitoring well, will be located north of the La Canada High School and approximately 2,000 feet southwest of JPL (Figure 4-10). When completed, MW-21 will be used to help evaluate groundwater flow into the southern part of the study area from the La Canada/Flintridge area and to provide information on the southern boundary of JPL's groundwater system. As a deep multi-port completion, the well will provide information on vertical differences in water quality. MW-21 will also be used for potentiometric-surface surveys. With monitoring of groundwater gradients and the potential distribution of constituents of interest in the groundwater in well MW-21, the use of this well as representing background conditions will be evaluated.

No monitoring wells are currently proposed to be installed west of JPL and Operable Unit 1. Information obtained from Operable Unit 1 monitoring wells MW-2, MW-6, and MW-14 will be evaluated to assess the need for additional well(s) further west of the facility.

Any additional new monitoring wells, if required, will be based on existing data at the completion of the scope of work presented within FSAP OU-1 and FSAP OU-3. The number, if any, and locations will be mutually agreeable to the regulatory agencies and to NASA and JPL.

4.2 SAMPLE FREQUENCY AND ANALYSES

As part of the RI, groundwater samples are proposed to be collected from all OU-3 monitoring wells during the dry season and wet season of the year. Based on the proposed RI schedule for OU-3, the initial set of samples would be collected near the fall of 1994 and represent the dry season. The second set of samples would be collected near the winter of 1995 and represent the wet season. NASA's Designated Project Manager (NDPM) will notify each regulatory agency's Project Manager not less than 10 days in advance of any sampling event as required in Section 22.2 of the FFA. Groundwater samples will be analyzed for VOCs, semi-volatile organic compounds (SVOCs), Title 26 metals (plus strontium), hexavalent chromium, cyanide, and general minerals (including major cations, major anions and Total Dissolved Solids (TDS)).

Samples of soil cuttings generated during well installation will be collected for two reasons only: (1) for lithologic identification during drilling operations and, (2) for analyses to characterize the soil cuttings for evaluating disposal options.

The analyses proposed for groundwater samples (and associated quality assurance samples) are discussed in Section 4.2.1, and the analyses proposed for the samples of soil cuttings are discussed in Section 4.2.2. All samples will be analyzed by a laboratory certified by the California Department of Health Services (CDHS) to conduct these analyses.

4.2.1 Groundwater Samples

The analytical methods proposed for the groundwater samples collected from JPL monitoring wells are summarized in Tables 4-4 and 4-5. These, or equivalent methods (with identical or lower detection limits), will be used to determine the nature and concentrations of potential contaminants in the groundwater. All analytical methods used will have detection limits at or below corresponding maximum contaminant levels (MCLs) (EPA, 1992a).

During the RI for OU-3, reports of groundwater analytical results transmitted from the laboratory for constituents of interest including VOCs, SVOCs, Title 26 metals (plus strontium), hexavalent chromium, and cyanide will include EPA Level IV CLP-type QA/QC data packages. All results obtained during the initial OU-3 sampling round shall be validated using EPA guidelines (see QAPP) as a check on laboratory performance.

During subsequent OU-3 sampling events, 10 percent of the data (nondetects as well as detects), plus all results above the State or Federal MCLs, will be validated using approved EPA guidelines as a continuing check on laboratory performance. All analytical data, after validation

TABLE 4-4

SUMMARY OF PROPOSED ANALYSES FOR GROUNDWATER SAMPLES AND SAMPLES OF SOIL CUTTINGS

Parameter	Proposed Analytical Method	Groundwater Samples	Duplicate Groundwater Samples	Groundwater Equipment Blanks	Groundwater Trip Blanks	Groundwater Field Blanks, Lab QA/QC Samples	Composited Samples of Soil Cuttings	Drilling Mud Samples
Constituents of Interest								
Volatile Organic Compounds	EPA 524.2	X	X	X	X	X		
Volatile Organic Compounds	EPA 8240						X	X
Semi-Volatile Organic Compounds	EPA 8270	X	X	X		X	X	X
Title 26 Metals (plus Strontium)	EPA 6010[1]	X	X	X		X	X	X
Hexavalent Chromium	EPA 7196/7197	X	X	X		X		
Cyanide	SW 9010						X	X
Cyanide	EPA 335.3	X	X	X		X		
Not Constituents of Interest[2]								
Total Petroleum Hydrocarbons	EPA 418.1						X	X
Major Cations[3]	EPA 200 Series	X	X					
Major Anions[4]	EPA 300 Series	X	X					
Total Dissolved Solids	EPA 160.1	X	X					

1: EPA Method 6010 will be used in all water and soil analyses except for arsenic (EPA 206.2); lead (EPA 239.2), antimony (EPA 204.2), selenium (EPA 270.2), thallium (EPA 279.2) and mercury (EPA 245.1). EPA 6010 detection limits for these metals in water exceed their respective drinking water MCLs.

2: Constituents added to RI to help evaluate flow patterns, groundwater impact on potential remediation equipment, etc.

3: Major cations include sodium, magnesium, potassium, calcium, and iron.

4: Major anions include fluorine, chlorine, nitrogen, and sulfate.

TABLE 4-5

SUMMARY OF THE FREQUENCY AND TYPE OF GROUNDWATER SAMPLES TO BE COLLECTED FOR ANALYSES FROM MP WELLS

Monitoring Well	Volatile Organic Compounds EPA 524.2	Semi-Volatile Organic Compounds EPA 8270	Title 26 Metals with Cr^{+6} and Strontium[1] EPA 6010/7000	Cyanide EPA 335.3	Major Cations and Anions EPA 200/300	TDS EPA 160.1	Duplicate Groundwater Sample	Groundwater Equipment Blank	Groundwater Trip Blank	Groundwater Field Blank
			Unfiltered				1 in 20; location may be modified	1 per day per type of equipment; location may be specified	1 per VOA shipment	1 per sampling round; location may be modified
MW-17										
Screen 1 (Top)	X	X	X	X	X	X				
Screen 2	X	X	X	X	X	X	X			
Screen 3	X	X	X	X	X	X				
Screen 4	X	X	X	X	X	X				
Screen 5 (Bottom)	X	X	X	X	X	X				
MW-18										
Screen 1	X	X	X	X	X	X				
Screen 2	X	X	X	X	X	X				
Screen 3	X	X	X	X	X	X				
Screen 4	X	X	X	X	X	X				
Screen 5	X	X	X	X	X	X				
MW-19										
Screen 1	X	X	X	X	X	X				
Screen 2	X	X	X	X	X	X				
Screen 3	X	X	X	X	X	X				
Screen 4	X	X	X	X	X	X				
Screen 5	X	X	X	X	X	X				

TABLE 4-5

SUMMARY OF THE FREQUENCY AND TYPE OF GROUNDWATER SAMPLES TO BE COLLECTED FOR ANALYSES FROM MP WELLS

Monitoring Well	Volatile Organic Compounds EPA 524.2	Semi-Volatile Organic Compounds EPA 8270	Title 26 Metals with Cr^{+6} and Strontium[1] EPA 6010/7000	Cyanide EPA 335.3	Major Cations and Anions EPA 200/300	TDS EPA 160.1	Duplicate Groundwater Sample	Groundwater Equipment Blank	Groundwater Trip Blank	Groundwater Field Blank
			Unfiltered				1 in 20; location may be modified	1 per day per type of equipment; location may be specified	1 per VOA shipment	1 per sampling round; location may be modified
MW-20										
Screen 1	X	X	X	X	X	X				
Screen 2	X	X	X	X	X	X				
Screen 3	X	X	X	X	X	X				
Screen 4	X	X	X	X	X	X				
Screen 5	X	X	X	X	X	X				
MW-21										
Screen 1	X	X	X	X	X	X				
Screen 2	X	X	X	X	X	X	X			
Screen 3	X	X	X	X	X	X				
Screen 4	X	X	X	X	X	X				
Screen 5	X	X	X	X	X	X				

Notes:

1: EPA Method 6010 will be used in all water analyses except for arsenic (EPA 206.2), lead (EPA 239.2), antimony (EPA 204.2), selenium (EPA 270.2), thallium (EPA 279.2), and mercury (EPA 245.1). EPA 6010 detection limits for these metals exceed their respective drinking water MCLs. For hexavalent chromium, EPA 7196/7197 will be used.

and/or evaluation, will be submitted to all involved regulatory agencies within 60 days of its collection as outlined in Section 22.1 of the FFA.

Reports of analytical results from the laboratory for general mineral analyses (major anions, cations, and total dissolved solids) will be presented with EPA Level III data packages. The general minerals data obtained during RI groundwater sampling events will not be used to identify RI constituents of interest, but have been added to the RI so that, when coupled with hydrologic observations, they may potentially be useful for (1) interpreting groundwater flow patterns and potential contaminant migration, (2) evaluating the possible effect of surface water runoff on groundwater quality, and (3) evaluating the effect of inorganic constituents on the performance of potential remediation equipment.

4.2.2 Field Quality Assurance Efforts

A field quality assurance (QA) sampling program will be enacted to evaluate the precision of the laboratory analyses, the effectiveness of decontaminating the sampling equipment, and sample-handling and bottle-preparation procedures. Collection of duplicate samples, equipment blanks, field blanks, laboratory QA/QC samples, and trip blanks will be included in this program. The proposed analyses to be used on field QA samples are summarized in Tables 4-4 and 4-5. The locations where these samples will be collected at are summarized in Table 4-5.

A duplicate and laboratory QA/QC groundwater sample will be collected from the second screened interval of proposed well MW-17 (downgradient to screen two of multi-port well MW-3 where volatile organics have been detected) and the second screened interval of proposed well MW-21 (upgradient monitoring well). Since no data is currently available from the locations of the proposed multi-port wells, the locations for the duplicate samples may be changed based on field observations or instrument readings taken during well installation activities. However, the final frequency of 1 sample for every 20 samples collected will be met as stated in the Quality Assurance Project Plan (QAPP). The results from the first round of sampling may change the proposed locations for the collection of the duplicate samples for the second sampling event. This will be implemented to ensure that duplicate samples will be collected at locations where the data may be most critical. The duplicate samples will be used to evaluate the precision of the laboratory analytical results. Duplicate samples will be analyzed for the same constituents of interest as the sample being duplicated.

Equipment blanks will be collected at a frequency of one per day of sampling per type of sampling equipment (see QAPP). Equipment blanks will be collected at the end of each sampling day. Equipment blanks will consist of ASTM Type II organic-free water, obtained from the laboratory, used as the final rinse after the sampling equipment has been decontaminated. Equipment blanks will be used to evaluate the effectiveness of the procedures used for decontaminating the sampling equipment and whether cross contamination between wells is occurring from sampling equipment. Equipment blanks will be analyzed for the same constituents of interest as the groundwater samples. Equipment blanks will not be analyzed for major anions, major cations or total dissolved solids because these constituents are not constituents of interest.

One field blank will be collected during each sampling round of the RI. The field blank will consist of sample bottles, filled with ASTM Type II organic-free water supplied by the laboratory, that are placed at the sampling point (well head) and left open during all sampling activities. After sampling, the sample bottles will be capped and analyzed for the same constituents of interest as the groundwater samples being collected to evaluate the influence that ambient conditions, or sample containers, may have on the analytical results (see QAPP). It is proposed that the field blank will be collected while well MW-17 is being sampled to assess if sample results are being influenced by emissions from vehicular traffic.

One trip blank will be submitted with each shipment of samples to the analytical laboratory. These samples will be used to monitor the integrity of the sample during transportation and will be analyzed for volatile organic compounds only.

4.2.3 Drill Cuttings Samples

Grab samples of soil cuttings will be collected below the conductor casing and at 100-foot intervals during the drilling of the monitoring wells (Table 4-6). In addition, if the field-screening instruments detect any VOC vapors from any soil cuttings during drilling, a grab sample of those cuttings will be collected and analyzed for VOCs, SVOCs, Title 26 metals (plus strontium), cyanide, and total petroleum hydrocarbons (TPH). The specific analytical methods proposed for these samples are summarized in Tables 4-4 and 4-5. The analytical results will be used to characterize the soil cuttings for disposal purposes only in accordance with applicable EPA guidance on the management of investigation-derived wastes (EPA, 1991 and 1992c). If soil cuttings are determined to be contaminated in any way, they will be stored on the site until the appropriate method of disposal can be arranged. The 90-day holding time for investigation-derived waste will not be exceeded.

4.3 HYDROGEOLOGIC PARAMETERS

To understand the nature of the OU-3 groundwater flow system and its interaction with OU-1 groundwater, it is necessary to measure and map the configurations of the water table on a

TABLE 4-6

SUMMARY OF THE FREQUENCY AND ANALYSES OF SOIL GRAB SAMPLES TO BE COLLECTED FROM MP WELLS

Depth[1] (feet)	Title 26 Metals and Strontium EPA 6010/7000	Volatile Organic Compounds EPA 8240	Semi-Volatile Organic Compounds EPA 8270	Total Petroleum Hydrocarbons EPA 418.1	Cyanide SW 9010
Below Conductor Casing	X	X	X	X	X
100	X	X	X	X	X
200	X	X	X	X	X
300	X	X	X	X	X
400	X	X	X	X	X
500	X	X	X	X	X
600	X	X	X	X	X
700	X	X	X	X	X
800	X	X	X	X	X
900	X	X	X	X	X

The laboratory will make a composite sample from all grab samples collected from each well and will analyze the composites for the parameters listed above.

Note:

1: The number of grab samples collected will vary for each monitoring well on the basis of each well's total depth. Additional samples will be collected at locations where VOC vapors are detected during drilling.

sampling events to characterize variations in the water table over time and the direction of groundwater flow both beneath the site and locally.

In the deep multi-port monitoring wells, the piezometric head at each sampling port will be measured with a pressure-transducer probe manufactured especially for the unique casing used in these wells. These measurements will be taken at a minimum, during all RI sampling events.

5.0 SAMPLE DESIGNATION

All groundwater samples and samples of soil cuttings will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. Sample labels will be filled out in waterproof indelible ink at the time of sampling and the following information will be included:

- Project/site name
- Sample identification
- Date and time of collection
- Name of sampler
- Analyses requested
- Preservatives used, if applicable
- Remarks, if any

Each groundwater sample will be designated with a unique alpha-numeric code. Each groundwater sample will be identified with "MW" (monitoring well), followed by a numeric identifier. The numeric identifier will be "1" for the first sample collected, and will increase sequentially as additional samples are collected. The trip blanks, duplicate samples, field blanks, and equipment blanks will each be labeled with the appropriate sequential numeric identifier as they are collected, or submitted, as is the case for the trip blanks. The date, time, and locations of each sample will be recorded on Well Development/Sampling Forms (Section 6.0) and in the permanently bound field log book. This sample labeling scheme will allow all samples to be sent "blind" to the analytical laboratory.

The sample identifiers used for the grab samples of soil cuttings collected during the drilling of the wells will also consist of a unique alpha-numeric code identifying the sample type. Each grab sample of soil cuttings will be identified with "SC" (soil cuttings), followed by a numeric identifier. The numeric identifier will be "1" for the first sample collected and will increase sequentially as additional samples are collected. The time, location, and depth of all soil-cuttings samples will be recorded on the boring log forms (Section 6.0) and in the permanently bound field logbook.

6.0 SAMPLING EQUIPMENT AND PROCEDURES

The sampling equipment and procedures to be used during the completion of the OU-3 field investigation are described in this section. Discussions of monitoring well installation procedures (Section 6.1), groundwater sampling procedures (Section 6.2), and drill cuttings sampling procedures (Section 6.3) are included.

6.1 MONITORING WELL INSTALLATION PROCEDURES

Currently, five groundwater monitoring wells are proposed to be installed off the JPL site during the OU-3 work. All five will be completed as deep multi-port (MP) wells as outlined in Section 6.1.2.

The proposed wells will be constructed in a manner consistent with the guidelines in "California Well Standards, Bulletin 74-90" (DWR, 1991) and applicable EPA guidance (EPA, 1992b). Permit requirements for the installation of the proposed wells are outlined in Section 6.1.1. The details of the drilling and installation of the deep MP wells are outlined in Section 6.1.2.

6.1.1 Well Permit Requirements

Pursuant to the National Contingency Plan, Subpart E, Section 300.400(e)(i), "No federal, state, or local permits are required for on-site response actions conducted pursuant to CERCLA...". However, prior to initiating field activities, local and state well permits will be obtained. A well permit for each of the proposed monitoring wells located outside JPLs boundaries and within the City of Pasadena, will be obtained from the City of Pasadena, Public Health Department, Environmental Health Division. A well permit for the proposed well located within the City of La Canada/Flintridge will be obtained from the County of Los Angeles Department of Health Services, Public Health Programs-Environmental Health. Before drilling begins a Notice of Intent Card for all proposed wells will also be completed and submitted to the State of California, Department of Water Resources - Southern District.

Copies of the required well permit application forms and the Notice of Intent are presented in Figure 6-1. Well permit requirements, fees, and agency contacts are summarized in Table 6-1.

Following the installation of each well, a well completion report form will be submitted to the State of California, Department of Water Resources. A copy of the well completion report form is shown in Figure 6-2. In addition, completed well logs with details of the well installation will be submitted to the County of Los Angeles Department of Health Services for the proposed well

TABLE 6-1

SUMMARY OF MONITORING WELL PERMITTING DETAILS

Agency	Applicable Well Locations	Contact	Permit Applications	Follow-up Requirements
County of Los Angeles Department of Health Services Public Health Programs Environmental Health 2525 Corporate Place Monterey Park, CA 91754	City of La Canada/ Flintridge	San Gabriel Valley area: Mr. Dave Kinney (818) 308-5374	Submit completed application forms with permit fee of $133/well a minimum of 2 weeks before work is to commence.	Submit completed well log with details of well installation (date, depth, screen interval, etc.) within ten days of well completion.
City of Pasadena Department of Public Health Environmental Health Division 100 N. Garfield Avenue Pasadena, CA 91101	City of Pasadena	Mr. Mel Lim (818) 405-4390	Submit letter specifying proposed start date, well location, well owner name and address, contractor's license number, and 2 copies of the proposed well construction plan with a permit fee of $154/well a minimum of 5 days before work is to commence.	None
State of California Department of Water Resources Southern District Post Office Box 29068 Glendale, CA 91209-9068	All monitoring wells.	None	Submit completed Notice of Intent Card at least 2 weeks before work is to commence.	Submit completed Well Completion Report forms within 90 days of well completion

Applications for a Well Permit from the County of Los Angeles Department of Health Services

SERVICE APPLICATION AND FEE COLLECTION
COUNTY OF LOS ANGELES - DEPARTMENT OF HEALTH SERVICES
PUBLIC HEALTH PROGRAMS - ENVIRONMENTAL HEALTH
SERVICE REQUEST APPLICATION

INSTRUCTIONS

1. Check the TYPE OF SERVICE requested and attach the required non-refundable fee to the application. Make money order or check payable to LOS ANGELES COUNTY TREASURER. DO NOT SEND CASH. This application is nontransferable.

FEE REQUIRED*		TYPE OF SERVICE
________	☐	MONITORING WELL CONSTRUCTION/DESTRUCTION
________	☐	WELL CONSTRUCTION, RENOVATION OR DESTRUCTION PERMIT Complete and attach a Well Permit Application
________	☐	PRIVATE SEWAGE DISPOSAL SYSTEM CONSTRUCTION PERMIT
________	☐	PRIVATE SEWAGE DISPOSAL SYSTEM RENOVATION/EXPANSION
________	☐	INSPECTION OF MOUNTAIN CABIN SITE as required by the United States Forest Service
________	☐	INSPECTION OF EXISTING PRIVATE SEWAGE SYSTEM as required by FHA/VA
________	☐	WATER SUPPLY TEST AND CERTIFICATION as required by U.S. Department of Agriculture

2. Check with Contact Office stamped below for requirements or information.
3. Complete the required information or deliver the completed application, money order or check with the forms indicated.

to: County of Los Angeles
Department of Health Services
Public Health Programs
Environmental Health
2525 Corporate Place
Monterey Park, Ca 91754
(213) 881-4147

*Refer to Schedule of Fees for current fiscal year.

NOTE: FIELD PERSONNEL CANNOT ACCEPT FEES.

4. Phone Contact Office noted below, after you have received your receipt, to request an inspection.

Service/Job Location Address ________ Date ________

Owner/Applicant's Name ________ Address ________ Phone No. ________

Contractor's Name ________ Address ________ Phone No. ________

Co. Engineer Plan Check No.____ Tract No. ________ Lot No. ________ No. Bedrooms ____
(Complete line above for Private Sewage Disposal System Construction or Renovation Application)

CONTACT OFFICE	DEPARTMENT STAMP

APPLICATION FOR WELL PERMIT
ENVIRONMENTAL HEALTH 2525 Corporate Place Monterey Park, Ca 91754
COUNTY OF LOS ANGELES DEPARTMENT OF HEALTH SERVICES

DATE ________

DESCRIPTION

TYPE OF PERMIT (CHECK)
☐ NEW WELL CONSTRUCTION
☐ RECONSTRUCTION OR RENOVATION
☐ DESTRUCTION

TYPE OF WELL
☐ PRIVATE DOMESTIC
☐ PUBLIC DOMESTIC
☐ IRRIGATION
☐ OBSERVATION/MONITORING
☐ CATHODIC
☐ INDUSTRIAL
☐ GRAVEL PACK
☐ TEST

TYPE OF CASING ________

METHOD OF SEALING OF CASING ________

METHOD OF DESTRUCTION ________

LOCATION

ADDRESS (NUMBER, STREET, AND NEAREST INTERSECTION) ________ CITY ________

DIAGRAM (SHOW PROPERTY LINES, STREET, ADDRESS, WELL SITE, SEWERS, AND PRIVATE SEWAGE DISPOSAL SYSTEMS ALONG WITH LABELS AND DIMENSIONS)

APPLICANT

NAME OF WELL DRILLER (PRINT) ________ NAME OF WELL OWNER (PRINT) ________

TRADE NAME ________ MAILING ADDRESS ________

BUSINESS ADDRESS ________ CITY ________ CITY ________

I hereby agree to comply in every respect with all regulations of the County Preventive/Public Health Services and with all ordinances and laws of the County of Los Angeles and of the State of California pertaining to well construction, reconstruction and destruction. Upon completion of well and within ten days thereafter, I will furnish the County Preventive/Public Health Services with a complete log of the well, giving date drilled, depth of well, all perforations in casing, and any other data deemed necessary by such County Preventive/Public Health Services.

____
Applicant's Signature

DISPOSITION OF APPLICATION: (For Sanitarians Use Only)
☐ APPROVED ☐ DENIED
☐ APPROVED WITH CONDITIONS

If denied or approved with conditions, report reason or conditions here

DATE ________ SANITARIAN ________
DATE ________ SECTION CHIEF ________

When signed by Section Chief, this application is a permit

Application for a Well Permit from the City of Pasadena Public Health Department

CONSTRUCTION PLAN APPLICATION FORM
CITY OF PASADENA
HEALTH DEPT.
ENVIRONMENTAL HEALTH DIVISION

№ 049

Plan Submitted By:________ Title:________ Date:________

Plans Submitted for:
Packaged food only ☐
New Construction ☐
Remodeling ☐
Facility now closed ☐

Maximum number of employees including owner at any given time ________

Alcoholic beverage served on premises yes ____ no ____

Seating Capacity________

If existing food establishment, give former DBA ________

New DBA

Address ________ City ________ ZIP ________

Owner ________ Address ________ Phone ________

Contractor ________ Address ________ Phone ________

Architect ________ Address ________ Phone ________

Business Classification ________ Fee:______ Date:________

Fund: 250118

Account No: 3235

I understand that the amount of the fee paid is based on my declaration of the business classification of the plans submitted. If this declaration is incorrect, I understand that the plan will not be approved (3 copies of the plan to be submitted).

Signature:________

Plans Approved by:________

SEE REVERSE SIDE FOR PAYMENT. Date:________

Date: ________ Rec'd By: ________

Notice of Intent from the State of California Department of Water Resources

ORIGINAL
FILE WITH DEPARTMENT OF WATER RESOURCES

No. 259864

NOTICE OF INTENT

DEPARTMENT OF WATER RESOURCES: ________, 19____

On or about ________, 19____, I plan to commence drilling ☐ deepening ☐ reconditioning ☐ or destruction of ☐ a cable ☐ rotary ☐ or other ________ type well, for ________ purposes. The work will be done for
(Proposed use of well)

____
(Name of client and address)

Approximate location of well is ________

____
(Legal subdivision or by reference to some landmark)

________, in ________ County.

________ Lic. No. ________
(Well driller)

____
(Address)

Need log forms ☐ Need notice cards ☐ DWR 2125

Figure 6-1

Application Forms for Well Permits and Notice of Intent Required to be Submitted Prior to Monitoring Well Installation

ORIGINAL
File with DWR

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 496751

Page ___ of ___
Owner's Well No. ___
Date Work Began ___ , Ended ___
Local Permit Agency ___
Permit No. ___ Permit Date ___

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ___ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft. to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*

TOTAL DEPTH OF BORING ___ (Feet)
TOTAL DEPTH OF COMPLETED WELL ___ (Feet)

WELL OWNER

Name ___
Mailing Address ___
CITY STATE ZIP

WELL LOCATION

Address ___
City ___
County ___
APN Book ___ Page ___ Parcel ___
or
Township ___ Range ___ Section ___
or
Latitude ___ NORTH Longitude ___ WEST
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

NORTH
WEST EAST
SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

___ NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USE(S) (✓)

___ MONITORING
WATER SUPPLY
___ Domestic
___ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD ___ FLUID ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL ___ (Ft.) & DATE MEASURED ___
ESTIMATED YIELD * ___ (GPM) & TEST TYPE ___
TEST LENGTH ___ (Hrs.) TOTAL DRAWDOWN ___ (Ft.)
* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft. to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft. to Ft.	TYPE: CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME ___
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS CITY STATE ZIP

Signed ___
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Required to be Submitted to the State of California
Department of Water Resources after Monitoring Wells Installed

Figure 6-2

State of California
Department of Water Resources
Well Completion Report Form

located within the City of La Canada/Flintridge. A copy of the well logs will also be presented in the RI report.

In addition to trying to meet all well permitting requirements, all permits and requirements needed from the cities of Pasadena and La Canada/Flintridge and the County of Los Angeles will be obtained for drilling and installing wells in public streets. County and city departments and contacts responsible for public works and transportation, public utilities, building and neighborhood services, and permit sections are presented in Table 6-2.

Because of the length of time it may require to process permit applications involving multiple city and county departments, the permitting process will begin no less than 60 days prior to field activities if possible.

In addition, permits will be required for subsequent groundwater monitoring and sampling events following the installation of the MP monitoring wells. The permits required are also listed in Table 6-2.

6.1.2 Deep Multi-Port Wells

The deep MP wells have been designed to sample the aquifer at five separate depths using a single casing. Similar systems have previously been installed on the site using casing components manufactured by Westbay Instruments Ltd. (Ebasco, 1990a). During OU-3 work, five additional deep MP wells will be constructed in the same manner. The drilling method, well construction details, and well development procedures for the deep wells are described in the following subsections.

6.1.2.1 Drilling Method

The deep MP monitoring wells will be drilled using a mud-rotary drilling rig. A pilot hole will be drilled to approximately 20 feet and a 16-inch-diameter, low-carbon steel conductor casing will be cemented in place before mud-rotary operations begin. Drilling will continue with a bit approximately 12.25 inches in diameter to maximum depths of approximately 500 to about 925 feet, depending upon the depth to the crystalline basement rocks. The drill bits and drill pipe used will be steam cleaned prior to use in each well. During mud-rotary drilling, pure bentonite drilling mud and hydrocarbon-free pipe dope will be used. The drilling mud will consist of American Petroleum Institute grade 200-mesh bentonite (Hydrogel®, Aquagel®, or Premium Gel®).

TABLE 6-2

SUMMARY OF CITY AND COUNTY DEPARTMENT CONTACTS FOR OFF-SITE MP WELL INSTALLATION PERMITTING REQUIREMENTS*

Agency	Department	Applicable Well Locations	Contact	Permit Applications	Follow-up Requirements
County of Los Angeles	Dept. of Public Works Road Department 818/338-9509	City of La Canada-Flintridge	Mr. Ron Foshay Engineer	• Encroachment Permits • Excavation Permits • Insurance	Encroachment permit required for each additional groundwater monitoring and sampling event.
City of La Canada-Flintridge	Building & Safety Division 818/790-8651	City of La Canada-Flintridge		• Noise Control Ordinance	None
City of Pasadena	Dept. of Public Works Permits Division 818/405-4195	City of Pasadena	Ms. Sandy Price	• Occupancy Permit (Encroachment permit) • Utility Permit (Excavation permit) • Insurance	Occupancy permit required for each aditional groundwater monitoring and sampling event.
	Dept. of Planning, Building, & Neighborhood Services 818/405-4431	City of Pasadena	Mr. Bill Schlecht	• Noise Control Ordinance	None

* CERCLA exempts the project in terms of obtaining permits. These permits will be obtained only if the project schedule is not impacted.

During drilling, the bentonite drilling mud will be monitored for weight, viscosity, and sand content with a mud scale, marsh funnel and cup, and a sand content kit. The properties of the mud will be at the discretion of the driller if hole stability, fluid loss, or equipment concerns arise. Under ideal conditions the mud weight will be kept below approximately 70 pounds per cubic foot, the viscosity between 40 and 60 seconds, and the sand content less than 4 percent. Mud-property data will be recorded on the field boring log form and will be checked after the hole has been circulated clean after approximately every 50 feet of drilling. Any mud property found to be out of tolerance will be immediately adjusted back into tolerance.

Clean, uncontaminated water will be used during mud-rotary drilling and construction of the wells. The clean water will be delivered to the site from an off-site supplier. A sample of the water will be collected after each delivery for analysis of VOCs using EPA Method 524.2.

During drilling operations, the drilling mud will be circulated out of the boring to a screened shaker and through a de-sander to separate the drill cuttings from the drilling mud. Drill cuttings will be collected in a roll-off bin and checked for organic vapors with a flame- or photo-ionization detector after every 10 feet or less of drilling. Grab samples of drill cuttings will be collected for laboratory analyses when drilling begins below the conductor casing, after every 100 feet of drilling, and when the field instruments indicate the presence of organic vapors. The individual samples of the cuttings will be sent to a CDHS-certified laboratory. The laboratory will make a composite sample from all discrete samples collected from each well and will analyze the composites for VOCs, SVOCs, cyanide, Title 26 metals plus strontium, and TPH. The laboratory results will be used to determine the best disposal method for the cuttings pursuant to EPA guidance on management of investigation-derived wastes (EPA, 1991 and 1992c). Drilling mud and drill cuttings will be moved onto the JPL site and stored while waiting on analytical data. If soil cuttings are determined to be contaminated in any way, they will remain on the site until the appropriate method of disposal can be arranged. Drilling fluids circulated out of the boring after mud-rotary drilling operations have been completed will be stored in large tanks or lined roll-off bins. Drilling fluid will also be moved onto the JPL site and stored temporarily. Samples of the drilling fluid will be collected from each tank or roll-off bin for laboratory analyses. The results of these analyses will be used to determine the proper disposal methods for the drilling fluid pursuant to EPA guidance on the management of investigation-derived wastes (EPA, 1991 and 1992c). All investigation-derived waste will be characterized in a timely efficient manner so as not to exceed the 90-day holding time.

Drill cuttings will also be evaluated after every 5 feet or less of drilling and described to document the underlying stratigraphy. Lithologic descriptions of the soil cuttings will be recorded on the field boring logs forms (Figure 6-3) and will include the following information:

EBASCO ENVIRONMENTAL

FIELD BORING LOG

LOCATION OF BORING/WELL:

DATUM:

OFS NUMBER

CLIENT/LOCATION

DRILLING CO./METHOD:

BORING/WELL NUMBER

SAMPLING METHOD:

SHEET OF

BACKGROUND CONDITIONS:

DRILLING

SURFACE CONDITIONS:

START	FINISH
TIME	TIME
DATE	DATE

NOTES:

GEOLOGIST: ______

REVIEWED BY: ______

TYPE OF INSTRUMENT/SERIAL #: ______

CALIBRATION DATE/GAS: ______

SAMPLING METHOD: ______

SAMPLING ANALYSIS: ______

PERSONAL H & S SAMPLES: ☐ YES ☐ NO

PERSON SAMPLED: ______

SAMPLE NUMBER / SAMPLE DEPTH	TIME	SAMPLER BLOWS/FT.	INCHES DRIVEN / INCHES RECOVERED	INSTRUMENT: AUGER	INSTRUMENT: SAMPLE	INSTRUMENT: BREATHING ZONE	DEPTH IN FEET	USCS SOIL TYPE
							0	
							1	
							2	
							3	
							4	
							5	
							6	
							7	
							8	
							9	
							0	
							1	
							2	
							3	
							4	
							5	
							6	
							7	
							8	
							9	
							0	
							1	

F-1

Figure 6-3

Sample Boring Log Form

- Physical characterization and grain-size distribution of the sample
- Stratigraphic boundaries
- Presence of any inferred visible contaminants
- Color changes
- Thickness of individual units
- Samples of cuttings collected
- Odor
- Any other conditions encountered during drilling (i.e., changes in drilling rate, difficulties, etc.)

All soil descriptions will be based on the Unified Soil Classification System (Figure 6-4). In addition to completing the field boring log form, all pertinent information relating to all aspects of field work will be recorded in the bound field logbook.

6.1.2.2 Well Construction

A typical design for a deep monitoring well is shown in Figure 6-5. The deep, MP wells will be constructed according to the following general procedures:

- The total depth of each deep well will be determined by the NASA Authorized Subcontractor Operable Unit Manager (OUM) based on the depth of the crystalline basement rocks. Each boring will be advanced approximately 15 feet once basement rock is encountered to confirm that the crystalline basement has been reached. It is estimated that the wells will range in depth from approximately 500 to more than 900 feet.
- After each well is drilled, a geophysical logging subcontractor will perform a natural-gamma radiation, an electrical resistivity (R/SP), a guard resistivity, and a caliper survey in each open hole to aid in lithologic characterization, stratigraphic correlation, and in determining well screen locations.

  The casing design for each well will begin conceptually by evenly distributing the five well screens vertically across the aquifer. Then, based on the interpretation of the geophysical logs and the boring log, this conceptual design will be modified by moving the proposed screen locations up or down a short distance until they are located adjacent to the sandiest, or "cleanest", and, therefore, relatively most permeable sections of the aquifer without inhibiting the ability of the well to adequately monitor the thickness of the aquifer. At this point the well design would be considered final and constructed according to the modified conceptual design. During previous investigations (Ebasco, 1990a), the resistivity curves most accurately reflected downhole lithologies. The sections of the borehole that appear to have the best water-yielding capabilities appear to have the highest electrical resistivities. The character of the spontaneous potential log is normally subdued because of the fact that fresh water drilling muds are used in a fresh-water aquifer. The amount of natural

Unified Soil Classification System

Major Divisions			USCS Symbol	Description
Coarse-Grained Soils More than half of material is larger than No. 200 Sieve Size	**Gravel** More than half of coarse fraction is larger than No. 4 Sieve Size	Clean Gravels (little or no fines)	GW	Well-graded gravel or gravel sand mixtures, little or no fines. (Wide range of grain sizes and substantial amounts of all intermediate particle sizes)
			GP	Poorly-graded gravels or gravel sand mixtures, little or no fines. (Predominately one size or range of sizes with some intermediate sizes missing)
		Gravels with Fines (appreciable amount of fines)	GM	Silty gravels, gravel-sand-clay mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	Sands More than half of coarse fraction is smaller than No. 4 Sieve Size	Clean Sands (little or no fines)	SW	Well-graded sands or gravelly sands, little or no fines. (Wide range of grain sizes and substantial amounts of all intermediate particle sizes)
			SP	Poorly-graded sands or gravelly sands, little or no fines. (Predominately one size or range of sizes with some intermediate sizes missing)
		Sands with Fines (appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
Fine-Grained Soils More than half of material is smaller than No. 200 Sieve Size	Silts and Clays		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silt-clays of low plasticity.
			MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity.
Highly Organic Soils			Pt	Peat and other highly organic soils. (Readily identified by color, odor, spongy feel, and frequently by fibrous texture.)

(For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 Sieve Size)

The No. 200 Sieve Size is about the smallest particle visible to the naked eye

PARTICLE SIZE LIMITS

SILT OR CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

No.200 — No.40 — No. 10 — No. 4 — 3/4 in — 3 in — (12 in)

U.S. STANDARD SIEVE SIZE

CONSISTENCY CLASSIFICATION

Granular Soil

Density	Abbrv.	Blows/Foot
Very Loose	VL	0 — 4
Loose	L	5 — 10
Medium Dense	MD	11 — 30
Dense	D	31 — 50
Very Dense	VD	Over 50

Bedrock	Abbrv.
Very Soft	VS
Soft	SO
Moderately Hard	MH
Hard	H
Very Hard	VH

Cohesive Soil

Consistency	Abbrv.	Field Identification
Very Soft	VS	Easily penetrated several inches by fist
Soft	SO	Easily penetrated several inches by thumb
Medium Stiff	MS	Can be penetrated several inches by thumb/moderate effort
Stiff	ST	Readily indented by thumb/penetrated only with great effort
Very Stiff	VS	Readily indented by thumbnail
Hard	H	Indented with difficulty by thumbnail

Soil Odor

Odor	Abbrv.
None	N
Light Hydrocarbon	LH
Mod. Hydrocarbon	MH
Strong Hydrocarbon	SH
Alcohol	A
Humis	H
Musty	M
Foul	F
Diesel	D
Gasoline	G
Sulfur	S
Turpentine	T

Soil Color

Color	Abbrv.
Light Brown	LB
Yellow Brown	YB
Brown	B
Dark Brown	DB
Grayish Brown	GB
Reddish Brown	RB
Dark Red	DR
Grayish Red	GR
Red	R
Yellowish Red	YR
White	W
Light Gray	LG
Gray	G
Dark Gray	DG
Yellow	Y
Pale Yellow	PY
Grayish Yellow	GY
Black	B
Tan	T
Light Red	LR

Moisture Condition

Condition	Abbrv.
Dry	DR
Slightly Moist	SM
Moist	MO
Wet	WT
Saturated	ST

Other Symbols

- R - Undisturbed sample
- B - Bulk Sample
- ▼ Ground water
- ✦ Groundwater sepage

Reference: Modified after the Unified Soil Classification System, Corps of Engineers, U.S. Army Technical Memorandum No. 3-357, Volume I, March, 1953 (Revised April, 1960)

Figure 6-4

Unified Soil Classification System

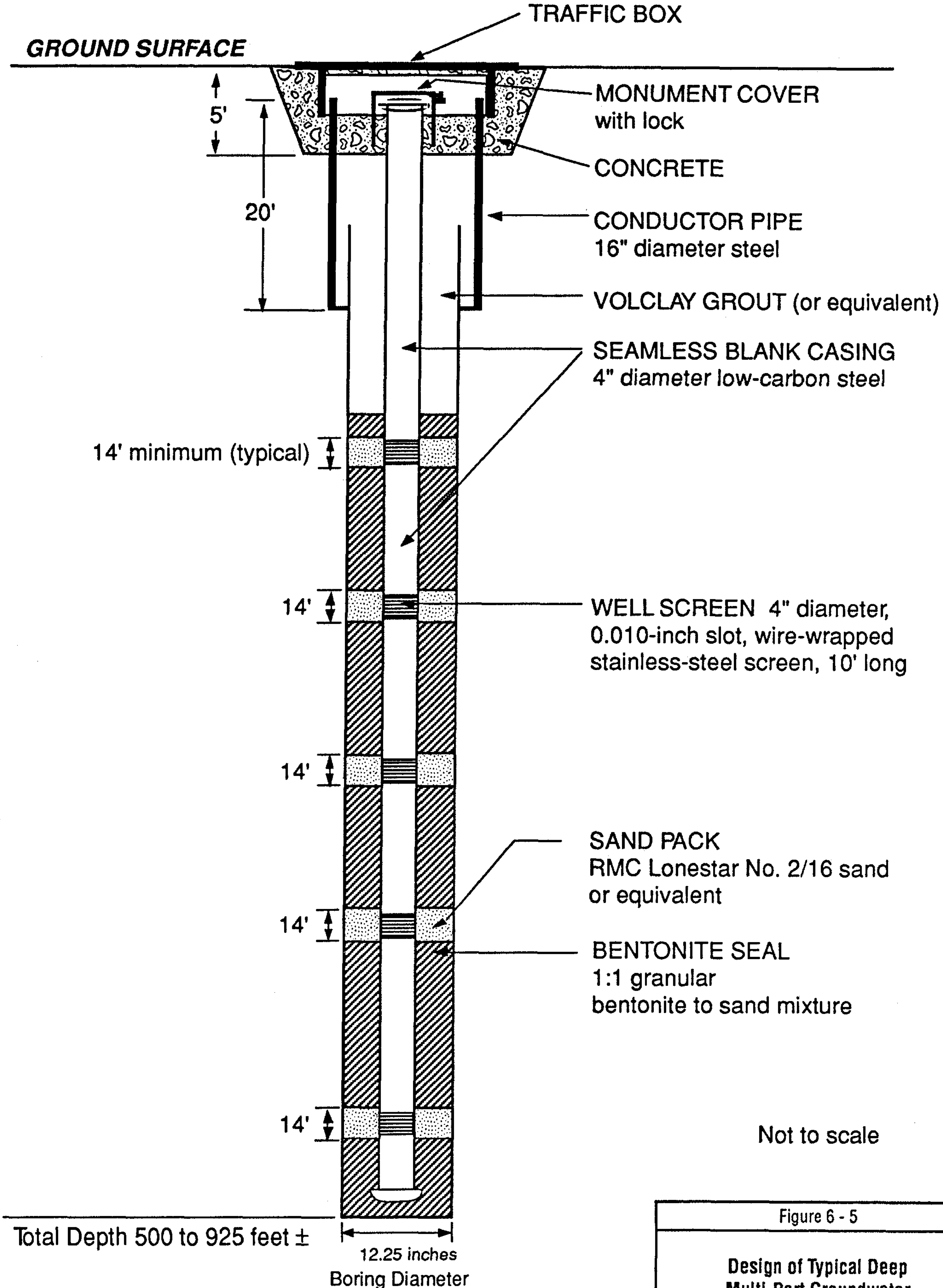


Figure 6 - 5

Design of Typical Deep Multi-Port Groundwater Monitoring Well

gamma radiation recorded is commonly the result of both the amount of clay present (high potassium content) and the amount of granitic material present (high potassium feldspar and biotite content) rendering lithology determinations from the natural gamma ray log at times unreliable.

- The well casing, consisting of sections of 4.0-inch-diameter low carbon steel blank casing and five, 10-foot-long, 4.0-inch-diameter, stainless steel wire-wrap screens with 0.010-inch slots welded together, will be lowered into each hole. Slot size is based on sieve analyses completed during a previous investigation (Ebasco, 1990a). Some sections of the blank casing will be cut to specified lengths to place the individual screens at the depths determined from review of the geophysical logs. Each section of screen and blank casing will be measured and steam cleaned before being lowered into the boring. Centralizers will be used to keep the casing in the center of the well boring. The centralizers will be located above the bottom cap, within 1 to 4 feet of the top and bottom of each well screen, and at 40-foot intervals along the blank casing.
- The casing will be hung in the well bore at the pre-determined depth (and not allowed to rest on the bottom of the borehole) during backfilling with construction materials. If the well bore is overdrilled, the overdrilled portion will be backfilled with a low permeability material such as bentonite mixture or grout. The bentonite seals and sand packs (Figure 6-5) will be tremied into place. A grout pump will be used to circulate drilling fluid out of the hole and to pump backfill materials into the boring. The backfill materials will consist of sand, a bentonite sealing mixture consisting of sand and bentonite, and Volclay® grout or equivalent. Next to the screened intervals, (a minimum of 2 feet above and below the screened interval) a clean, kiln-dried RMC Lonestar® #2/16 sand or equivalent will be used. Where a bentonite seal is required, a 1:1 mixture of pure bentonite granules and RMC Lonestar® #2/16 sand or equivalent will be placed in the boring. The backfilling procedure will be carefully monitored with frequent depth measurements. The remainder of the backfill will consist of Volclay® grout or equivalent (Figure 6-5).
- A locking monument cover or a traffic box will be installed at each well after the grout has set. Concrete will be used to secure the monument cover or traffic box in place. Traffic posts will be installed when a monument cover is used. The posts will be painted a bright color for easy recognition. When a traffic box is used, it will be set slightly above grade so surface water drainage is away from the well.

6.1.2.3 Well Development Procedures

Each MP well will be initially developed 12 to 24 hours after being installed. Each well screen will be initially developed by mechanical surging using a surge block. The surge block normally consists of two leather or rubber discs existing between three steel or wooden discs. The outside diameter of the leather or rubber discs is equal to or slightly less than the inside diameter of the screen. The steel or wooden blocks will be approximately 1 inch less than the inside diameter of the well screen. Development will begin at the top of the well screen and move progressively downward to prevent sand locking. Surging shall continue for 15 to 20 minutes followed by removal of the collected sediments by bailing. The two operations shall alternate until little or no sand is being pulled into the well.

Following swabbing and bailing operations, each screened interval will be individually pumped using either a submersible pump or an air-lift system isolated at each screen interval. Pumping will occasionally be discontinued to surge the interval being developed. The screened interval being pumped will be isolated from the other screened intervals in the well using nitrile rubber packers inflated with compressed nitrogen. The progress of the development of each screened interval will be measured by monitoring the physical properties of the water produced (pH, electrical conductivity, temperature, and turbidity). When the pH, conductivity and temperature approach stability (when two successive measurements made approximately three minutes apart are within approximately 10 percent of each other) and turbidity is approximately 5 nephelometric turbidity units (NTUs) or less, the screened interval being developed will be considered ready for the installation of the MP casing. Development activities will be recorded on a well development/sampling log form.

All development water will be moved onto the JPL site and stored until appropriate disposal is arranged. Samples of the development water will be collected from each tank for laboratory analyses. The results of these analyses will be used to determine the proper disposal methods for the development water pursuant to the EPA guidance on the management of investigation-derived wastes (EPA, 1991 and 1992c).

6.1.2.4 Multi-Port (MP) Casing System Installation

The MP casing system is a multi-level groundwater monitoring system capable of providing access to each of the five isolated screened intervals within each deep well. The basic concept of the MP system is simple. It consists of a single, closed access tube with valved ports which provide access to several screened intervals within a single well casing. Nitrile rubber inflatable packers are used to seal the annulus between the measurement and pumping ports at each screened interval.

Each MP casing component arrives on the site pre-cleaned by the manufacturer and packed in plastic bags for transport. The MP casing system consists of various components including 1.5-inch-diameter schedule 80 PVC blank casing, PVC couplings used to connect various casing components, PVC measurement-port couplings that allow access to the aquifer for pressure measurements and water sampling, PVC pumping-port couplings that allow access to the aquifer for well purging and hydraulic conductivity testing, and nitrile rubber inflatable packers that are used to seal the annulus between the measurement and pumping ports at each screened interval (Figure 6-6).

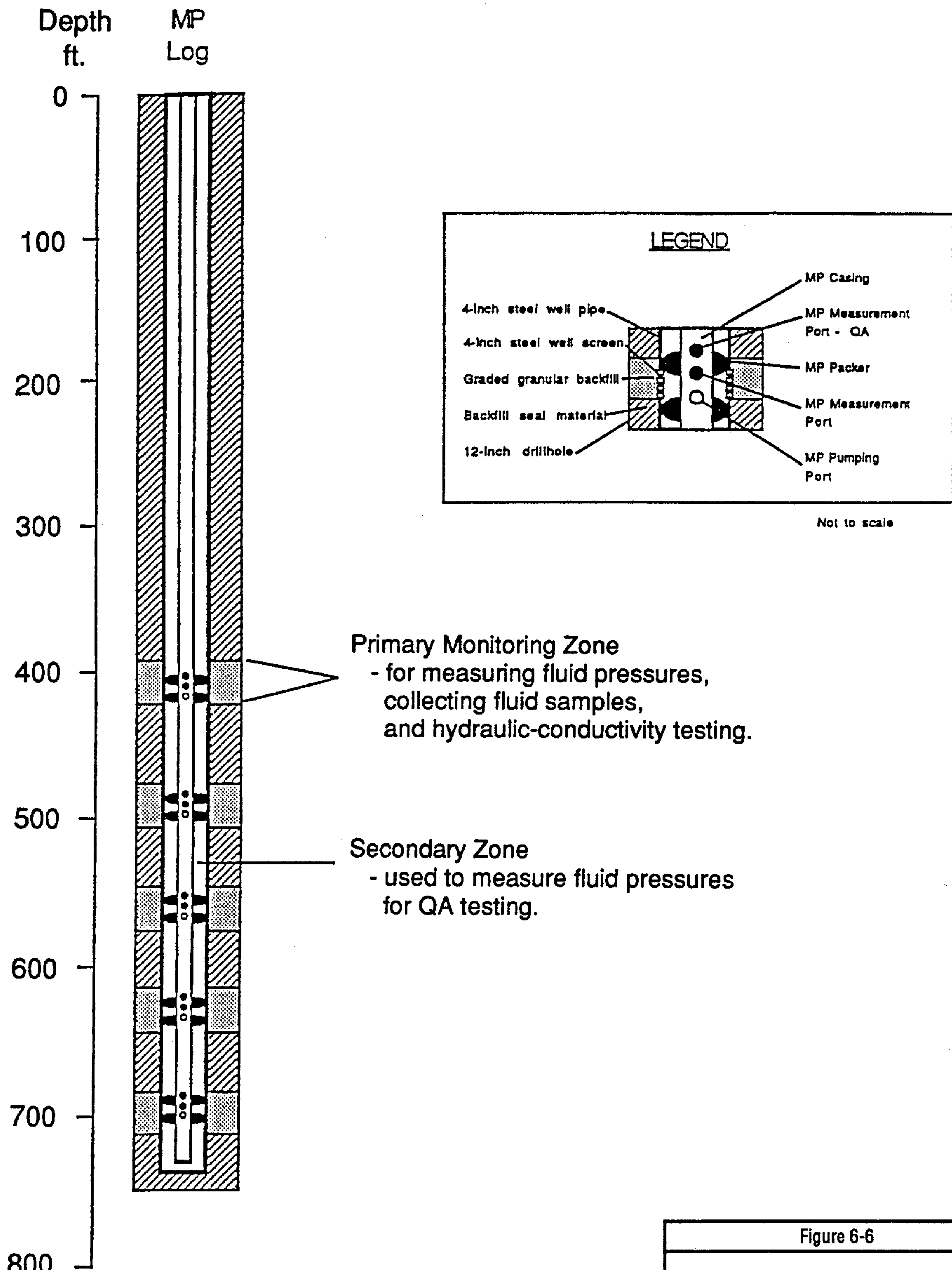


Figure 6-6

A Typical Multi-Port System Installation

The MP casing string will be assembled and installed by certified technical representatives of Westbay Instruments, Inc. Installation will be done by lowering the casing segments into the 4-inch-diameter steel casing by hand and attaching each successive segment to the adjacent coupling one at a time. Each coupling will be pressure tested before it is run into the hole to verify the integrity of the system during installation. To pressure-test each coupling, a probe with two small packers will be lowered into the casing so that the packers are located on each side of the coupling. The small packers will be inflated and water will then be injected under pressure into the casing opposite the coupling. If the coupling does not leak, it will be lowered into the well. Once the MP casing has been placed in each well, the nitrile rubber packers between screen intervals will be inflated. The packers are inflated with water, one at a time beginning with the lowest packer, using a downhole tool designed for this purpose. A casing installation log is used to accurately place the packers and measurement ports at the desired depths. After installation, several additional QA/QC checks will be performed. These checks will include an initial pressure profile to confirm the operation of the measurement ports and observation of head differences across the packers to confirm that the packers have properly sealed the annulus. The operation and detailed descriptions of the equipment and procedures used during MP casing installation and procedures for the required QA/QC checks are included in Appendix A.

After installation of the MP casing system, each screened interval will be developed further using a gas-lift (compressed nitrogen) pumping system or a small inertial pumping system (flexible plastic tubing with check valve at bottom connected to a reciprocating motor at the surface). Prior to commencing development activities in the MP casing, the piezometric pressure at each screen interval will be measured inside and outside the casing to ensure that formation water will flow into the casing when the pumping ports are opened for well development. Operation of the pressure measurement equipment is detailed in Appendix A.

The water level within the MP casing will be adjusted by bailing if necessary to assure that this condition is maintained during development activities at each screen interval. Each screened interval will be developed by opening the pumping-port valve at that screen and purging water from the screen interval using the pumping system selected. Pumping will occasionally be discontinued to allow discharge water to fall and lightly surge the formation. The physical and chemical properties of the development water will be monitored and recorded on a well development/sampling log form.

The screen interval will be considered developed when the pH, conductivity, temperature, and turbidity measurements reach stability (when two successive measurements made approximately 3 minutes apart are within approximately 10 percent of each other), and three well volumes of screened-interval water has been produced. All pertinent events which occur during development activities will also be entered in the bound field logbook.

6.2 GROUNDWATER SAMPLING

Groundwater samples are proposed to be collected from all five off-site MP monitoring wells during a dry season and a wet season of the year. The new monitoring wells will be sampled in an inferred order of possible increasing VOC content to minimize the potential for cross-contamination between wells. The initial round of groundwater sampling for the new MP wells will be done after waiting a minimum time period of 5 to 7 days after the final MP well has been developed. The time delay will maximize sample representativeness. The MP monitoring wells will be sampled with specialized equipment provided by Westbay Instruments, Inc. The necessary equipment and procedures for the collection of groundwater samples are discussed in Section 6.2.1. The proposed groundwater sampling activities are an integral part of the RI program. Related to these sampling activities is the development of data quality objectives (DQOs).

During groundwater sampling for the RI at JPL, EPA Level IV data packages will be generated by the laboratory for analyses of volatile organic compounds, semi-volatile organic compounds, Title 26 metals (plus strontium), hexavalent chromium, and cyanide. During subsequent RI sampling events, only 10 percent of the data (including non-detects and detects), plus all results above state or Federal MCLs, will be validated using approved EPA guidelines as a continuing check on laboratory performance.

The general minerals (major cations and major anions) and total dissolved solids analyses of groundwater samples will be performed using EPA Level III protocols, and will be reported with EPA Level III QA/QC documentation since these constituents are not constituents of concern. During the RI, some Level I and Level II data will also be collected; however, these data will be collected primarily during field sampling activities for health and safety purposes (see Section 7.0 of HASP) and to characterize water purged during well development and sampling (temperature, pH, specific conductivity, and turbidity).

6.2.1 Required Equipment

Sampling the MP monitoring wells requires specialized pressure profiling (MP-38 MOSDAX®) and sampling equipment manufactured by Westbay Instruments, Inc. This equipment includes a sampler probe and a pressure profiling probe with surface control units (Model 2410 Sampler Probe System and Model 2521 MOSDAX Pressure Profiling System). The personnel using this equipment must be trained for these systems to ensure their proper use. Training and certification is provided by Westbay Instruments, Inc. (the manufacturer). Copies of the detailed operations manuals for the Westbay sampling probe and pressure probe are included as Appendices B and C respectively. A probe battery pack with charger, four 250-milliliter stainless steel non-vented sample bottles with fittings and coupling hoses, a manual reel with 1,000 feet of coaxial cable and appropriate connectors, and a tripod with sheave and cable counter are also required to sample the MP wells. A powered winch with 1,000 feet of coaxial cable and connectors, a boom with sheave and cable counter, a 110-volt generator, and a winch control unit may be used instead of the manual reel and tripod. Additional equipment needed for well sampling is included in Table 6-3.

6.2.2 Decontamination Procedures

All sampling equipment used in the collection of groundwater samples will be decontaminated prior to use. Personnel directly involved in sampling equipment decontamination will wear protective clothing as specified in the Health and Safety Plan (HASP). Decontamination wastewater will be stored in a portable tank or drum(s), sampled, and analyzed to determine proper disposal pursuant to EPA guidance on the management of investigation-derived wastes (EPA, 1991 and 1992c). All decontamination water that meets drinking water standards will be disposed of on the site.

Westbay Sampler Decontamination

The Westbay sampling probe, Teflon® tubing, and sample bottles will be decontaminated prior to the sampling of each screened interval in each deep MP well. Before rented Westbay equipment is used at the site, the interior of the hoses used to connect the 250-ml sample bottles will be lined with new 1/8-inch-OD Teflon® tubing. If the Westbay equipment has been dedicated, this procedure will not be required. The Westbay sampling probe, and the valves and Teflon®-lined hoses connecting the sample bottles will be decontaminated by the following procedures:

- The interior surfaces of the Westbay sampling probe, and the hoses and valves associated with the Westbay sample bottles will be decontaminated by forcing a minimum of three volumes of a non-phosphate detergent (Liquinox®) and distilled or deionized water solution through them followed by forcing a minimum of three volumes of an acid detergent (Citranox®) and distilled or deionized water solution through them with a clean plastic squeeze bottle used only for this purpose.
- All components will be rinsed by forcing a minimum of three volumes of distilled or deionized water through them using a clean plastic squeeze bottle used only for this purpose.
- Collect an equipment blank, if required.

TABLE 6-3

EQUIPMENT INVENTORY CHECKLIST FOR GROUNDWATER SAMPLING AT THE JET PROPULSION LABORATORY

- ____ Field Sampling and Analysis Plan
- ____ Chain-of-Custody Forms
- ____ Well Development/Sampling Forms
- ____ Equipment Calibration Forms
- ____ Field Logbook
- ____ Pens and Pencils
- ____ Calculator
- ____ Important Names and Phone Numbers
- ____ Hard Hat
- ____ Nitrile Gloves
- ____ Safety Glasses
- ____ Steel-Toed Boots
- ____ First-Aid Kit
- ____ Three Large Trash Cans
- ____ Self-Sealing Plastic Bags
- ____ Cooler(s) with Ice
- ____ Distilled or Deionized Water
- ____ Non-Phosphate Detergent
- ____ 5-Gallon Buckets, Brushes
- ____ Scissors, Wrenches, Pliers, Screwdrivers, etc.
- ____ Electronic Water Level Meter
  - Spare Batteries (9 Volt)
  - 300 Feet Graduated Cable

- ____ Combination Salinity-Conductivity-Temperature Meter
  - Spare "D" Batteries
- ____ Organic Vapor Analyzer (Foxboro OVA 108)
  - Calibration Gases
    1) 95 ppm Methane
    2) 0.95% Methane
  - Adjustable Wrench
- ____ Organic Vapor Meter (OVM) (if OVA not available):
  - Isobutylene Standard
  - Collapsible Polyethylene Bag
- ____ Combination pH/Temperature Meter (Orion)
  - Ross Combination Electrode
  - Automatic Temperature Compensation (ATC) Electrode
  - Buffer Solutions (pH 4.00, pH 7.00, pH 10.00)
  - 3M KCl Electrode Fill Solution
  - Beakers or Jars for Buffers and Samples
  - Spare Batteries
- ____ Turbidity Meter with Standards

From Subcontracted Laboratory

- ____ All required sample bottles with appropriate preservatives and sample labels

Additional Equipment for Deep MP Well Sampling:

- ____ 12 Volt Soldering Iron and Solder
- ____ Water Trap
- ____ Vacuum Collar Assembly
- ____ 1/8-inch OD Teflon Tubing with Fittings
- ____ Vacuum Pump
- ____ End Extraction Jig (Cable Head)
- ____ Appropriate adaptor for Cable Head and Sampling Pressure Probes
- ____ Colored Plastic Tape
- ____ 2 to 3-foot 1/4-inch Dowel

Spare Parts Kits for:

- ____ Sampler Probe
- ____ Pressure Transducer Probe
- ____ Sample Bottle Valves
- ____ Cable Head
- ____ 10 each #004 and #006 Viton O-Rings

The threaded stainless steel sample bottles (tubes) will be decontaminated by the following procedures:

- Disassemble the sample bottles and wash each component in a solution of non-phosphate detergent (Liquinox®) and distilled or deionized water followed by washing each component in a solution of an acid detergent (Cirtanox®) and distilled or deionized water. The interior surfaces of the sample bottles can be washed by pushing lint-free paper wipes (such as Kim Wipes®) through each bottle with a clean wooden dowel. The exterior surfaces of the sample bottles will be scrubbed using a clean plastic brush.
- Rinse the sample bottles and their components twice with distilled or deionized water.
- Reassemble the sample bottles and collect an equipment blank, if required.

6.2.3 Purging Procedures

Purging before sampling is not required in the MP monitoring wells because the groundwater is not exposed to the atmosphere. Only the first sampler volume of groundwater retrieved from each screened interval in the MP wells is discarded prior to sampling. This volume of water is used as a rinse before samples are collected for analysis.

6.2.4 Measurement of Field Parameters and Field Instrumentation Calibration

Since purging is not required in the MP monitoring wells, temperature, pH, specific conductivity, and turbidity of the groundwater will be measured before and after each sample is collected from these wells. The time and measured value of each of these parameters will be recorded on the well development/sampling log form (Figure 6-7).

The instruments used to measure the temperature, pH, specific conductivity and turbidity of the groundwater will meet the measurement standards specified in the QAPP. The suite of instruments, or equivalent, which will be used at JPL include:

- Orion Model SA520 pH meter. This instrument is capable of measuring both pH and temperature. The pH measurements can be automatically corrected for temperature at the time of measurement.
- Yellow Springs Instrument Co. Model 33 conductivity/salinity meter. This instrument is capable of measuring electrical conductivity, salinity and temperature.
- Hach Model 16800 turbidimeter. This instrument measures the turbidity of water.

EBASCO ENVIRONMENTAL

WELL DEVELOPMENT / SAMPLING LOG

Project Name : ______________ Well Number : ______________
Project Number : ______________ Equipment : ______________
Date : ______________ ______________
Site Engineer : ______________ Contractor : ______________

	Before	*Reference Point*	*After*
Depth to Water (ft)	______	______	______
Depth to Sediment (ft)	______	______	______
Thickness of Sediment (ft)	______		______

Depth of Well (ft) ______ Water Column Height (ft) ______
Diameter of Casing (ft) ______
Casing Volume (gals) = π(Diam. of Casing (ft)/2)^2(Water Column Height (ft))(7.48 gals/ft^3) = ______

Total Volume Purged (gals) ______ Casing Volumes Purged ______

Time	pH	Turbidity (NTU)	Temp. (°C)	Conductivity (μmhos)	Pump Rate (gpm)	Comments

Notes Sampling Procedures: ______________

Figure 6-7

Well Development/ Sampling Log Form

These instruments are all battery powered and appropriate for use in a field environment. Different instrumentation (manufacturer and/or model number), if used, will be equivalent to those above.

Periodic maintenance and calibration of field instruments will be completed as specified by the instrument manufacturer. Depending upon the specific instrument, this may include sending the instrument to the manufacturer for periodic inspection and calibration, periodic office calibration and maintenance, or maintenance by the manufacturer on an as-needed basis. Copies of operation manuals, and any calibration certifications will be kept with the instrumentation in the field.

Field calibration, or standardization, of the instruments used will be performed on a daily basis and recorded on specific forms. These calibrations or standardizations will be done to manufacturer specifications. Examples of the forms which will be used for field calibrations of the pH, temperature and conductivity, and turbidity meters are provided in Figures 6-8, 6-9, and 6-10, respectively. Calibrations or standardizations of field instruments will be performed at the beginning of each day of sampling and checked again at the end of each day of sampling. Instrument-specific field calibration procedures and copies of each of the manuals for the pH meter, temperature and conductivity meter, and turbidity meter currently used at JPL are included in Appendices D, E, and F, respectively.

6.2.5 Collection of Groundwater Samples

Groundwater samples collected will be analyzed for VOCs, SVOCs, Title 26 metals (plus strontium), hexavalent chromium, cyanide, general minerals (major anions and cations) and TDS. The specific analytical methods to be used by the laboratory are summarized in Table 6-4 along with the requirements for containers, detection limits, and preservatives. The sample container requirements have been designed by a CDHS-certified laboratory to minimize sample volume required, but at the same time not jeopardize the integrity of the sample or the analyses as required by EPA guidance. Collecting extra, unnecessary volumes of groundwater from the deep Westbay wells is very time consuming and costly. The order in which samples will be collected is specified in "RCRA Groundwater Monitoring: Draft Technical Guidance" (EPA, 1992). Groundwater samples for VOCs will be collected first, SVOCs second, Title 26 metals with strontium and hexavalent chromium (currently includes major cations) third, cyanide fourth, and major anions fifth.

When samples for VOCs are collected, the stream of water from the sampling device will flow smoothly, with no turbulence, onto the inside wall of the sample container to minimize sample agitation. All sample bottles will be filled completely and not allowed to overflow, capped,

pH/TEMPERATURE METER FIELD CALIBRATION FORM

Project Name: ______________________________

Calibration by: ______________________________ Date: ______________

Instrument Manufacturer: ______________________ Model: ______________

Serial Number: ______________________

pH Probe Manufacturer: ______________________ Model: ______________

Serial Number: ______________________

ATC Probe Manufacturer: ______________________ Model: ______________

Serial Number: ______________________

Buffer Solution Manufacturer: ______________________

Expiration Dates of Buffer Solutions pH 4.01: __________ pH 7.00: __________ pH 10.01: __________

INSTRUMENTATION CHECK-OUT

Time: ______________________ Battery Condition: ______________________

Instrument Readings with Shorting Plug in, mV: ______ Temperature: ______ pH: ______ ISO: ______

Reference Chamber Solution Changed ?: ______________________

pH Probe Condition: ______________________

FIELD CALIBRATION

Time: ______________ Slope: ______________ Temperature: ______________

Response to Low Buffer: ______________ Response to High Buffer: ______________

Time: ______________ Slope: ______________ Temperature: ______________

Response to Low Buffer: ______________ Response to High Buffer: ______________

Time: ______________ Slope: ______________ Temperature: ______________

Response to Low Buffer: ______________ Response to High Buffer: ______________

Comments: ______________________________

E-12

Calibrate to Accuracy of ± 0.05 pH Units
Slope Must Be Between 80 - 110%

Figure 6-8

pH Meter Field Calibration Form

CONDUCTIVITY/SALINITY/TEMPERATURE METER FIELD CALIBRATION FORM

Project Name: ______________________________

Calibration by: ______________________________ Date: ______________

Instrument Manufacturer: ______________________ Model: ______________

Serial Number: ______________________________ Calibration Date: ______________

Probe Manufacturer: ______________________________ Model: ______________

Serial Number: ______________________________

Calibration Solution Manufacturer: ______________________________

Solution Conductivity: ______________________________ Expiration Date: ______________

FIELD CALIBRATION

Time: ______________ Temperature: ______________

Temperature Compensated Solution Conductivity (μ S/cm) ______________

Instrument Response: ______________ Probe Constant: ______________

Time: ______________ Temperature: ______________

Temperature Compensated Solution Conductivity (μ S/cm) ______________

Instrument Response: ______________ Probe Constant: ______________

Time: ______________ Temperature: ______________

Temperature Compensated Solution Conductivity (μ S/cm) ______________

Instrument Response: ______________ Probe Constant: ______________

The Temperature Compensated Solution Conductivity May Be Computed Using:
Conductivity (μ S/cm) = (Conductivity at 25°C) $(A + BT + CT^2)$
Where T = Temperature in °C

And

Conductivity @ 25°C (μ S/cm)	A	B	C
1,000	0.5407	0.0173	0.000043
10,000	0.5538	0.0168	0.000042
100,000	0.5825	0.0157	0.000040

Probe Constant = Temperature Compensated Solution Conductivity/Instrument Response

<u>Instrument is Calibrated if Response is:</u>

± 6% of calibration solution if reading is ≤ 150 μmhos/cm on 500 scale; ≤ 1500 μmhos/cm on 5000 Scale; or ≤ 15,000 μmhos/cm on 50,000 scale.

± 4.5% to 6% of calibration solution if reading is > 150 and < 300 μmhos/cm on 500 scale; > 1500 and < 3000 μmhos/cm an 5000 scale; and > 15,000 and < 30,000 μmhos/cm on 50,000 Scale.

± 4.5% of calibration solution if reading is ≥ 300 μmhos/cm on 500 scale; ≥ 3000 μmhos/cm on 5000 scale; and ≥ 30,000 μmhos/cm on 50,000 scale.

Figure 6-9

Conductivity/Temperature Meter Field Calibration Form

TURBIDIMETER FIELD STANDARDIZATION FORM

Project Name: ______________________________

Standardization by: ______________________ Date: __________

Instrument Manufacturer: ______________________ Model: __________

Serial Number: ______________________ Calibration Date: __________

STANDARDIZATION

Time: __________ Scale: __________ Zero: __________ Stray Light: __________
Standard NTU: ______________ Reading: ______________
Standard NTU: ______________ Reading: ______________

Time: __________ Scale: __________ Zero: __________ Stray Light: __________
Standard NTU: ______________ Reading: ______________
Standard NTU: ______________ Reading: ______________

Time: __________ Scale: __________ Zero: __________ Stray Light: __________
Standard NTU: ______________ Reading: ______________
Standard NTU: ______________ Reading: ______________

Time: __________ Scale: __________ Zero: __________ Stray Light: __________
Standard NTU: ______________ Reading: ______________
Standard NTU: ______________ Reading: ______________

Time: __________ Scale: __________ Zero: __________ Stray Light: __________
Standard NTU: ______________ Reading: ______________
Standard NTU: ______________ Reading: ______________

Time: __________ Scale: __________ Zero: __________ Stray Light: __________
Standard NTU: ______________ Reading: ______________
Standard NTU: ______________ Reading: ______________

Time: __________ Scale: __________ Zero: __________ Stray Light: __________
Standard NTU: ______________ Reading: ______________
Standard NTU: ______________ Reading: ______________

Comments: ______________________________

E-12

Figure 6-10

Turbidity Meter Field Standardization Form

TABLE 6-4

SUMMARY OF LABORATORY ANALYSES AND CONTAINER REQUIREMENTS FOR GROUNDWATER SAMPLES

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Volatile Organic Compounds	EPA 524.2	3 x 40 ml amber vial	4 drops HCl to pH <2; Cool to 4°C	7 days	
Benzene					0.5 μg/l
Vinyl chloride					0.5 μg/l
Carbon tetrachloride					0.5 μg/l
1,2-Dichloroethane					0.5 μg/l
Trichloroethylene					0.5 μg/l
1,4-Dichlorobenzene					0.5 μg/l
1,1-Dichloroethylene					0.5 μg/l
1,1,1-Trichloroethane					0.5 μg/l
Bromobenzene					0.5 μg/l
Bromodichloromethane					0.5 μg/l
Bromoform					0.5 μg/l
Bromomethane					0.5 μg/l
Chlorobenzene					0.5 μg/l
Chlorodibromomethane					0.5 μg/l
Chloroethane					0.5 μg/l
Chloroform					0.5 μg/l
Chloromethane					0.5 μg/l
o-Chlorotoluene					0.5 μg/l
p-Chlorotoluene					0.5 μg/l
Dibromomethane					0.5 μg/l
1,3-Dichlorobenzene					0.5 μg/l
1,2-Dichlorobenzene					0.5 μg/l
trans-1,2-Dichloroethylene					0.5 μg/l
cis-1,2-Dichloroethylene					0.5 μg/l
Dichloromethane					0.5 μg/l
1,1-Dichloroethane					0.5 μg/l
1,1-Dichloropropene					0.5 μg/l
1,2-Dichloropropane					0.5 μg/l
1,3-Dichloropropane					0.5 μg/l
cis-1,3-Dichloropropene					0.2 μg/l
trans-1,3-Dichloropropene					0.5 μg/l
2,2-Dichloropropane					0.5 μg/l
Ethyl benzene					0.5 μg/l
Styrene					0.5 μg/l
1,1,2-Trichloroethane					0.5 μg/l
1,1,1,2-Tetrachloroethane					0.5 μg/l
1,1,2,2-Tetrachloroethane					0.5 μg/l
Tetrachloroethylene					0.5 μg/l
1,2,3-Trichloropropane					0.5 μg/l
Toluene					0.5 μg/l

TABLE 6-4

(Continued)

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
m,p-Xylenes					0.5 μg/l
o-Xylene					0.5 μg/l
Bromochloromethane					0.5 μg/l
n-Butylbenzene					0.5 μg/l
Dichlorodifluoromethane					0.5 μg/l
Fluorotrichloromethane					0.5 μg/l
Hexachlorobutadiene					0.5 μg/l
Isopropylbenzene					0.5 μg/l
p-Isopropyltoluene					0.5 μg/l
Naphthalene					0.5 μg/l
n-Propylbenzene					0.5 μg/l
sec-Butylbenzene					0.5 μg/l
tert-Butylbenzene					0.5 μg/l
1,2,3-Trichlorobenzene					0.5 μg/l
1,2,4-Trichlorobenzene					0.5 μg/l
1,2,4-Trimethylbenzene					0.5 μg/l
1,3,5-Trimethylbenzene					0.5 μg/l
2-Butanone (MEK)					5.0 μg/l
4-Methyl-2-Pentanone					5.0 μg/l
Trichlorotrifluoroethane					0.5 μg/l
Title 26 Metals + Sr		500 ml Polyethylene	2 ml HNO_3 to pH <2; Cool to 4°C		
Silver (Ag)	6010			6 months	10 μg/l
Arsenic (As)	206.2			6 months	5 μg/l
Barium (Ba)	6010			6 months	50 μg/l
Beryllium (Be)	6010			6 months	4 μg/l
Cadmium (Cd)	6010			6 months	5 μg/l
Cobalt (Co)	6010			6 months	50 μg/l
Copper (Cu)	6010			6 months	10 μg/l
Chromium	6010			6 months	10 μg/l
Mercury (Hg)	245.1			28 days	2 μg/l
Molybdenum (Mo)	6010			6 months	50 μg/l
Nickel (Ni)	6010			6 months	40 μg/l
Lead (Pb)	239.2			6 months	2 μg/l
Antimony (Sb)	204.2			6 months	6 μg/l
Selenium (Se)	270.2			6 months	5 μg/l
Thallium (Tl)	279.2			6 months	2 μg/l
Vanadium (V)	6010			6 months	50 μg/l
Strontium (Sr)	6010			6 months	10 μg/l
Zinc (Zn)	6010			6 months	20 μg/l
Major Cations					
Calcium (Ca)	215.1			6 months	1000 μg/l
Magnesium (Mg)	242.1			6 months	1000 μg/l
Sodium (Na)	273.1			6 months	1000 μg/l
Potassium (K)	258.1			6 months	1000 μg/l
Iron (Fe)	200.7/6010			6 months	100 μg/l

TABLE 6-4

(Continued)

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Chromium (Hexavalent)	218.5	125 ml polyethylene	Cool to 4°C	24 hours	5 µg/l
Cyanide	335.3	125 ml Polyethylene	0.5 ml of 50% NaOH to pH >12; Cool to 4°C	14 days	5 µg/l
Major Anions		500 ml Polyethylene	Cool to 4°C		
Alkalinity (Bicarbonate)	310.1			14 days	2 mg/l
Chloride	300			14 days	1000 µg/l
Sulfate	300			14 days	2000 µg/l
Nitrate (as N)	300			48 hours	100 µg/l
Fluoride	340.2			14 days	100 µg/l
Total Dissolved Solids	160.1			7 days	10 mg/l
pH	150.1	-	-	field	0.01 units
Specific Conductance	120.1	-	-	field	4 umhos/cm
Total Phosphate	365.4	125 ml Polyethylene	0.5 ml H_2SO_4 to pH <2; Cool to 4°C	28 days	50 µg/l
Semi-Volatile Organic Compounds	EPA 8270	2x1000 ml glass	Cool to 4°C	Extraction w/in 14 days; Analysis w/in 40 days	
Phenol					10 µg/l
bis(2-chloroethyl)ether					10 µg/l
2-Chlorophenol					10 µg/l
1,3-Dichlorobenzene					10 µg/l
1,4-Dichlorobenzene					10 µg/l
Benzyl Alcohol					10 µg/l
1,2-Dichlorobenzene					10 µg/l
2-Methylphenol					10 µg/l
bis(2-chloroisopropyl)ether					10 µg/l
4-Methylphenol					10 µg/l
N-nitroso-di-n-dipropylamine					10 µg/l
Hexachloroethane					10 µg/l
Nitrobenzene					10 µg/l
Isophorone					10 µg/l
2-Nitrophenol					10 µg/l
2,4-Dimethylphenol					10 µg/l
Benzoic Acid					50 µg/l
bis(2-chloroethoxy)methane					10 µg/l
2,4-Dichlorophenol					10 µg/l
1,2,4-Trichlorobenzene					10 µg/l
Naphthalene					10 µg/l
4-Chloroaniline					10 µg/l
Hexachlorobutadiene					10 µg/l
4-Chloro-3-methylphenol					10 µg/l
2-Methylnaphthalene					10 µg/l

TABLE 6-4
(Continued)

Parameter	Method	Container	Preservative	Maximum Holding Time	Detection Limits
Hexachlorocyclopentadiene					10 µg/l
2,4,6-Trichlorophenol					10 µg/l
2,4,5-Trichlorophenol					50 µg/l
2-Chloronaphthalene					10 µg/l
2-Nitroaniline					50 µg/l
Dimethylphthalate					10 µg/l
Acenaphthylene					10 µg/l
2,6-Dinitrotoluene					10 µg/l
3-Nitroaniline					50 µg/l
Acenaphthene					10 µg/l
2,4-Dinitrophenol					50 µg/l
4-Nitrophenol					50 µg/l
Dibenzofuran					10 µg/l
2,4-Dinitrotoluene					10 µg/l
Diethylphthalate					10 µg/l
4-Chlorophenyl-phenyl ether					10 µg/l
Fluorene					10 µg/l
4-Nitroaniline					50 µg/l
4,6-Dinitro-2-methylphenol					50 µg/l
N-nitrosodiphenylamine					10 µg/l
4-Bromophenyl-phenylether					10 µg/l
Hexachlorobenzene					10 µg/l
Pentachlorophenol					50 µg/l
Phenanthrene					10 µg/l
Anthracene					10 µg/l
Di-n-butylphthalate					10 µg/l
Fluoranthene					10 µg/l
Pyrene					10 µg/l
Butylbenzylphthalate					10 µg/l
3,3'-Dichlorobenzidine					20 µg/l
Benzo(a)anthracene					10 µg/l
Chrysene					10 µg/l
bis(2-ethylhexyl)phthalate					10 µg/l
Di-n-octylphthalate					10 µg/l
Benzo(b)fluoranthene					10 µg/l
Benzo(k)fluoranthene					10 µg/l
Benzo(a)pyrene					10 µg/l
Indeno(1,2,3-cd)pyrene					10 µg/l
Dibenzo(a,h)anthracene					10 µg/l
Benzo(g,h,i,)perylene					10 µg/l

Notes: Method detection limits are highly matrix-dependent and may vary slightly. The detection limits listed herein are provided for guidance.

labeled, and placed on ice in a cooler immediately after sample collection. Samples collected for VOCs will have zero headspace. If an air bubble is observed in the vial, a new sample must be collected.

All samples for metals analyses (including strontium, hexavalent chromium, anions and cations, and TDS) will be sent to the laboratory unfiltered. During the RI, at the discretion of NASA, in addition to the unfiltered samples, filtered samples for metals analyses (including hexavalent chromium, strontium, anions and cations) may be sent to the laboratory for analyses. To collect the filtered samples, a disposable 0.45 micron cartridge filter will be attached to the end of the discharge hose of the pump, or the end of the Westbay sample bottles. A manually operated hand pump will be used to drive the water through the filter when the MP monitoring wells are sampled.

6.3 DRILL CUTTINGS SAMPLING

During the drilling of additional monitoring wells at JPL, grab samples of the soil cuttings will be collected at the specified intervals (Section 4.2.2) and used to characterize the soil cuttings for disposal purposes only. In addition, samples of drilling fluids will be collected at the completion of drilling operations to characterize the mud for disposal purposes only. The equipment, sample containers, and procedures used in the collection of these samples are discussed below in Sections 6.3.2 and 6.3.5.

6.3.1 Data Quality Objectives

The data quality objectives for OU-3 are presented in the RI/FS Work Plan. For the soil cuttings and drilling fluid samples to be collected during the RI for OU-3, EPA Level III data will be generated for analyses of VOCs, SVOCs, Title 26 metals plus strontium, cyanide, and TPH. The laboratory will report the results with Level III QA/QC documentation. These data will be used to characterize the soil cuttings and drilling fluids generated during well installation activities for disposal purposes in accordance with applicable EPA guidance on the management of investigation-derived wastes (EPA, 1991 and 1992c). During the RI, all soil cuttings and drilling mud will be stored or containerized with appropriate security. The soil cuttings will be moved onto JPL after field activities are completed at each well location. If soil cuttings are determined to be contaminated in any way, they will be stored at JPL during the duration of the 90-day storage limit until the appropriate method of disposal can be arranged.

6.3.2 Required Equipment

Grab samples of soil cuttings will be collected from their point of discharge from the drilling rig in 8 ounce wide-mouth glass jars provided by the subcontracted laboratory. Drilling cuttings will be collected with a wire-screen collander or a metal scraper.

6.3.3 Decontamination Procedures

The wire screen collander and/or scraper to be used in collecting the grab samples of soil cuttings will be washed in a solution of non-phosphate detergent (Liquinox®) and distilled or deionized water, and rinsed twice in distilled or deionized water. If there is a delay before this equipment is used, it will be wrapped in plastic to prevent incidental contact with potentially contaminated objects.

6.3.4 Field Instrumentation and Calibration

A photo-ionization detector (PID) or a flame-ionization detector (FID) will be used to screen the soil cuttings for VOC vapors for health and safety purposes. Details of these instruments and their calibration are included in the site HASP.

6.3.5 Collection of Soil Cuttings and Drilling Fluid Samples

Samples of soil cuttings will be collected during drilling operations from just below the conductor casing and after approximately every 100 feet of drilling in the deep MP well borings and whenever the field instruments indicate the presence of volatile organic vapors.

Soil cuttings will be collected from the mud discharge pipe at the conductor casing with a wire-screen-collander or, if inaccessible, from the shaker screen and de-sanding unit on the portable mud pits. A scraper will be used to collect soil cuttings off the shaker screen or de-sanding unit. All soil cuttings samples will be capped, labeled, and placed in an ice chest and cooled to 4 degrees Celsius immediately after sampling. The specific analyses proposed and maximum holding times are summarized in Table 6-5.

The drilling fluids used during the drilling of the deep MP monitoring wells will be kept on the site in large portable tanks or lined roll-off bins. Drilling fluid samples will be collected from these tanks for analysis at the completion of drilling activities. Drilling mud samples (one from each portable tank of drilling mud) will be analyzed for VOCs, SVOCs, Title 26 Metals plus strontium, cyanide, and TPH to determine disposal options for the drilling mud. The specific analyses proposed, sample containers, and maximum holding times are summarized in Table 6-5.

TABLE 6-5

SUMMARY OF ANALYSES FOR COMPOSITE SAMPLES OF SOIL CUTTINGS AND SAMPLES OF DRILLING FLUIDS

Parameter	Method	Holding Time	Containers		Preservatives for Drilling Mud Samples
			Soil	Drilling Mud	
Volatile Organic Compounds	EPA 8240	7 days	8 ounce glass jars	3x40 ml glass vials	Cool to 4°C
Semi-Volatile Organic Compounds	EPA 8270	Extraction w/in 14 days; Analysis w/in 40 days;		2x1000 ml glass	Cool to 4°C
Title 26 Metals plus Strontium	EPA 6010/7000	6 months Mercury - 28 days		500 ml polyethylene	Cool to 4°C
Total Petroleum Hydrocarbons	EPA 418.1	28 days		1000 ml glass	Cool to 4°C
Cyanide[1]	SW 9010	14 days		1000 ml polyethylene	Cool to 4°C

Note:

1: Only composite drill cutting samples will be analyzed for cyanide.

7.0 SAMPLING HANDLING AND ANALYSIS

Analyses of all samples will be performed by a laboratory certified by the California Department of Health Services for the analyses being performed. Maximum holding times for each analytical method will be strictly observed (see QAPP). Laboratory reports of the analytical results will be reviewed according to QA procedures described in the QAPP.

7.1 SAMPLE CONTAINERS AND PRESERVATIVES

All containers for water samples will be precleaned by the subcontracted laboratory according to EPA QC procedures. To achieve optimal sample preservation, the laboratory will add the appropriate preservatives to water sample containers, if necessary, immediately prior to shipment to the site. The types of containers and preservatives, and the amount of preservatives required, for specified water analyses are indicated in Table 6-4.

Once opened, a container will be used immediately for the collection of a particular sample. Unused, but opened containers will be considered contaminated and will be discarded. Any unused container, which upon receipt, is found to have a loose cap or missing Teflon® liner (if required for that container) will be discarded.

7.2 SAMPLE TRANSPORT AND CUSTODY

Sample labels will be attached to the sample containers prior to sample collection. After collection, custody seals and sample tags will also be added to each sample container (see QAPP). The sample containers will then be sealed in resealable plastic bags to prevent the loss of labels during shipment. All samples will be placed in a cooler with ice to ensure that they remain at a temperature of 4 degrees Celsius until delivery to the laboratory. A thermometer will be placed in each ice chest and checked periodically to assure the samples are at 4 degrees Celsius. These readings will be recorded in the bound field logbook. Glass sample containers will be securely packaged with bubble wrap in the coolers to avoid breakage.

Chain-of-custody procedures will be used to maintain and document sample possession for legal purposes. Adherence to strict document control procedures is of prime importance. The principal documents that will be used to record possession of the samples are the chain-of-custody forms and the field notes. A sample is considered to be in a person's custody if (1) it is in a person's physical possession, (2) it is in view of the person after that person has taken possession, (3) it is secured by that person so that no one can tamper with the sample, and (4) it is secured by that person in an area to which access is restricted.

Chain-of-custody forms (Figure 7-1) will be completed and will accompany the samples to the laboratory. The field sampler (originator) will be responsible for the care and custody of the samples from the time they are collected until they are transferred to another individual. All samples will be transported to the laboratory by courier, a laboratory representative or other NASA authorized personnel, therefore ensuring prompt, secure arrival and meeting the requirements of chain-of-custody procedures. For each sample shipment, the originator will complete a chain-of-custody form entering all the requested information. At a minimum the form will contain the following:

- Sample Number
- Signature of sampler
- Date and time of sample collection
- Sample type
- Signature of persons involved in the chain of possession
- Date and time of relinquishment
- Analyses required
- Identification of samples laboratory can utilize for duplicate or matrix spike analyses.

Upon receipt of the sample at the laboratory, the designated sample custodian will proceed as outlined in the QAPP. Persons relinquishing samples will sign the chain-of-custody form in the appropriate box labelled "relinquished by" and will retain a copy. The sample recipient will cross-check the sample label and the chain-of-custody form. The recipient will also examine the samples and document any unusual conditions in the "Remarks" section on the chain-of-custody form. The persons relinquishing and receiving the sample will sign the chain-of-custody in the appropriate boxes labelled "relinquished by" and "received by" respectively. Along with their signatures they will note the date and time of the exchange. All sample shipments will be accompanied by the original chain-of-custody form. The remaining copies will be maintained in the project file.

CHAIN OF CUSTODY FORM REQUEST FOR ANALYSIS

EBASCO ENVIRONMENTAL
A Division of Ebasco Services Incorporated
3000 W. MacArthur Boulevard, Santa Ana, California 92704-6993 • (714) 662-4050 • Fax (714) 662-4049

Page ___ of ___

Project:
OFS No.
Project Address:
Sampler (Name):
Sampler: *(Signature)*:
Laboratory:
Reports to Be Sent to:

HAZARD IDENTIFICATION:
Nonhazard ☐ Reactive ☐
Flammable ☐ Toxic ☐
Skin Irritant ☐ Infectious ☐

Time Required
NORMAL ☐ ____ DAYS
RUSH ☐ ____ DAYS

ANALYSES REQUIRED

THE INFORMATION IN THIS SECTION WILL NOT BE AVAILABLE TO THE LABORATORY

SAMPLE NUMBER	TIME COLLECTED	DATE COLLECTED	NUMBER OF CONTAINERS	CONTAINER SIZE(S)	SAMPLE MATERIAL			ANALYSES REQUIRED										LOCATION	DEPTH	QC CODE
					WATER	SOIL	OTHER *(Describe)*													

LABORATORY INSTRUCTIONS/COMMENTS:

SAMPLING COMMENTS:

Relinquished by: *(Signature)*	Date:	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date:	Received by: *(Signature)*
Company:	Time:	Company:	Company:	Time:	Company:

F-2

Shipping Copy (White) File Copy (Canary) Field Copy (Pink)

Figure 7-1

Chain-of-Custody Form

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APPENDIX A

DETAILS ON WESTBAY MULTI-PORT SYSTEM COMPONENTS, DESIGN AND QA/QC PROCEDURES

Westbay
Instruments Inc.

Multi-Level Groundwater Monitoring with the MP System

FIELD TRAINING NOTES©

For: EBASCO
Date: February, 1990
Place: NASA Jet Propulsion Laboratory, Pasadena, CA

Date	REVISIONS	Pages	Initials
Aug 02, 89	Updating of Field Forms, Cover Page, MP Training Session, Multi - level Data section	-	MDR
Aug 25,89	Calculation sheets added for: packer inflation pressure, installation forces (tensile/compression)	-	MDR

Printed in Canada

507 E.Third Street, North Vancouver, B.C., Canada V7L 1G4 Phone (604) 984-4215 Fax (604) 984-3538 Phone (in U.S.) (800) 663-8770

MP System Overview and Operator Training Program

1. Introduction

1.1 About Westbay

1.1.1 Company Profile

Westbay Instruments Inc. was established in 1973 to undertake development, manufacture, installation and servicing of quality-engineered groundwater monitoring and sampling equipment. A number of patents on Westbay instrumentation have been issued or are pending in Canada, the United States, the United Kingdom and Japan.

Westbay's primary product, the MP System, has been used since 1978 in studies of slope stability, foundation performance, environmental impact assessment, nuclear waste management and groundwater contamination. During 1982-1983 Westbay developed a complete line of stainless steel casing components for the MP System. Applications for the stainless steel MP System include site characterization and monitoring for nuclear waste management, geothermal or earthquake monitoring and petroleum reservoir instrumentation.

Westbay operates from its head office and plant in North Vancouver, British Columbia, Canada where it manufactures its own probes and tools, assembles and tests all casing components and provides repair and maintenance services. Experienced Westbay personnel are available for services varying from design of monitoring systems, installations and training to providing turnkey operations and periodic monitoring services. The company continues to be involved in research and development of new products.

Internationally, Westbay is represented in Japan by the OYO Corporation and the Shimizu Corporation, in the United Kingdom by Soil Mechanics Ltd, and in Italy by ISMES.

1.1.2 The MP System

The MP System is a modular multiple-level groundwater monitoring system employing a single, closed access tube with valved ports. The valved ports are used to provide access to several different levels of a drillhole in a single well casing. The modular design permits as many monitoring zones as desired to be established in a drillhole. Furthermore, at the time of installation, zones may be added or modified without affecting other zones or significantly complicating the installation. The MP System is described in detail in a technical paper by Black et al (1986).

The ability to economically provide high quality, verifiable monitoring data from multiple monitoring zones gives the MP System many technical advantages over alternative monitoring methods. Ease of operation, corroboration of data, and quality of monitoring information are particularly important when the hydrogeologic or geochemical conditions are complex, or the cost of remediation is high.

The MP System has particular application in monitoring groundwater flows in hydrogeologic environments where water quality and pressures can undergo large changes in short distances. Such environments can include fractured rock, where high anisotropy, variable degree of fracture interconnecting and rapid groundwater flow velocities are commonly encountered. Closely spaced multiple-level monitoring zones provide an invaluable tool to help the groundwater professional identify and assess important groundwater flow paths and design appropriate remediation measures.

1.1.3 Technical Personnel

Westbay's staff of engineers and technicians are a highly skilled team of groundwater professionals. Westbay engineers routinely assist with the design of monitoring wells, implementation of monitoring protocols, analysis of data and preparation of reports. Westbay representatives are also responsible for properly training the clients' designated personnel in the operation and maintenance of MP System tools and equipment.

1.2 Scope of Presentation

1.3 Examples of MP System Applications

1.3.1. Bridge Pier Foundation Study
Annacis Island, Delta, B.C.

1.3.2 Groundwater Characterization of Abandoned Oil Refinery
Hazardous Waste Management Facility, Cody, Wyoming

1.3.3 Groundwater Quality Investigation by Orange County Water District, California

1.4 General Overview of the MP System

2. Monitoring Well Design

The proposed monitoring well would be designed to meet the monitoring objectives taking into consideration the drillhole conditions and the MP System capabilities. The following sections briefly describe these factors and the effect they may have on the design of the monitoring well. Please contact Westbay for additional information.

2.1 Hydrogeologic Information Required

The intended use of the monitoring well will have a significant impact on the monitoring well design. Typical uses include pressure monitoring, fluid and gas sampling, hydraulic conductivity testing, and axial deformation monitoring.

Factors to be considered include:

- number of monitoring zones required
- number of packers required
- positioning of packers
- number of measurement ports required
- positioning of measurement ports
- number of pumping ports
- positioning of pumping ports
- purging requirement, if applicable
- redundant components for quality assurance

2.2 MP System Component Selection

2.2.1 Geology

Complexity of geology and structure affects the number of monitoring zones that may be required to properly understand the site.

2.2.2 Expected Pressure Profile

Prior knowledge of groundwater conditions affects the number of monitoring zones required as well as which type of casing may or may not be suitable.

2.2.3 Temperature

The known or anticipated groundwater temperature may limit the suitability of certain casing materials, packer materials, etc. The groundwater temperature should not exceed 30 degrees C when standard MP packers with urethane packer elements are used.

2.2.4 MP System

In the design phase of the MP monitoring well, the physical capabilities of the MP System components must be considered. During installation both tensile and compressive axial loads are developed on the MP casing. These loads along with the expected operating conditions of the MP System may dictate which kind of MP System would be acceptable for use. The three kinds of MP System are described below (see Table 1).

Plastic MP System

Plastic casing and plastic couplings with shear wire tensile connection and o-ring seals. Generally suitable for installation in holes to depths of 500 m if water levels are high and groundwater temperature is less than 30 degrees C. Designed to operate under nominal differential pressures of 7 kg/cm^2 (100 psi) (inside over outside, outside over inside, or across packers).

Plastic/Steel MP System

Plastic casing and stainless steel couplings with shear wire tensile connection and o-ring seals. Has been installed to depths of 1,200 m. Maximum depth varies with number of packers used if packers mounted on steel casings. Groundwater temperature should be less than 30 degrees C. Capability to withstand differential pressures can be varied to suit requirements. Has been built to operate under nominal differentials of 20 kg/cm^2 (300 psi).

Stainless Steel MP System

Stainless steel casing and stainless steel couplings with threaded tensile connection and o-ring seals. Designed for installation to depths of 1,500 m. Has been installed to depths of 1,200 m. Depth capability varies with number and type of packers used. With urethane packer elements groundwater temperature should not exceed 30 degrees C. Alternate packer materials can be used for higher temperature applications. Capability to withstand differential pressures can be varied to suit requirements. Has been built to operate under nominal differentials of 30 kg/cm^2 and 40 kg/cm^2 (450 psi and 600 psi).

2.2.4.1 Casing Components

Measurement Ports

Measurement port couplings are used for measuring fluid pressure and taking discrete fluid samples. Additional measurement ports may be included in order to allow additional QA testing of packer seals.

Pumping Ports

Pumping port couplings are used for purging monitoring zones following installation. Also used for hydraulic conductivity testing and for Q/A testing of packer seals.

Packers

Packers are used for sealing the annulus of the drillhole between monitoring zones. Each standard packer element provides an 80 to 90 cm seal length in a 75 to 100 mm diameter hole. A number of different packer types may be used with the MP System - Table 2 indicates the operating temperature and differential pressure specifications for the 38 mm I.D. MP System packers.

Casing and Regular Couplings

The casing is required to provide access for monitoring tools to valved couplings. Various lengths are used depending on the degree of flexibility of valved port positioning desired. Regular couplings connect casings and packers wherever ported couplings are not used. Regular couplings also provide a vertical location reference for installation and monitoring tools.

Settlement Casing

Telescopic casing sections which allow axial movement of the MP casing. These can be used to prevent damage of casing when subjected to ground settlement or heave. Settlement tool can be used to measure the distance to couplings in the MP casing, providing a means of monitoring settlement or heave.

Auxillary MP Casing Components

Well screens are mounted around measurement port/pumping port combinations in backfilled installations and in installations in loose, fine-grained environments.

Magnetic location collars can be placed on the outside of the MP casing prior to installation. Instruments and tools with magnetic sensors can detect the magnetic field when lowered in the casing and emit an audible tone at the surface. The collars can be used to confirm the location of instruments in the well, particularly in very deep installations.

2.2.4.2 Monitoring Tools

Electric System

Electric pressure probes and sampler probes are designed for operation to depths of 1,500 m (5,000 ft). Both the pressure probe and water sampling probe may be operated on one reel with electric cable. They are commonly operated on manual cable reels to depths of 300 m (1,000 ft) and on powered reels to greater depths. With the proper accessories, the electric instruments can sense the magnetic location collars. The instruments require a 12 volt DC, 1/2 Amp power source to operate.

Pneumatic System

Pneumatic pressure probes and sampler probes are designed for operation to depths of 75 m (250 ft). Both the pressure probe and sampler probe may be operated on one reel with pneumatic tubing. The instruments require a regulated source of compressed gas at a pressure of 28 - 32 kg/cm2 (400 - 450 psi) to operate.

Open/Close Tool

Required for opening and closing pumping port coupling valves. The standard open/close tool operates on a reel with plain stainless steel cable. With an accessory kit, the open/close tool can operate on electric cable and sense magnetic location couplings.

Settlement Tool

A settlement tool and surveyor's tape are used to measure the distance from the top of an MP installation to the couplings above and below each settlement casing. Tensioning and measuring the length can be done by simple hand-held tensioner and sighting on the top of the MP casing or by using a precise tensioner and vernier mounted on a reference at the top of the MP casing.

MOSDAX

MOSDAX, currently under development, is a new electronics package which will allow several probes to be installed at measurement ports in each well. The system could be used for unattended long-term monitoring or for monitoring short term tests (cross-hole permeability tests, etc.).

Monitoring of pressure and transducer temperature can be carried out automatically with the surface control unit storing the data until required or passing it on to a computer. The measured temperature and stored calibration data will be used to correct the transducer output. One pair of conductors will be used to network up to 100 sensors. The maximum scan rate at present is on the order of 7 readings per second for a probe.

2.3 Drillhole Conditions

2.3.1 Diameter

The diameter of the drillhole directly affects the acceptability of a chosen annulus sealing method. Standard MP casing packers are suited to holes ranging from 75 to 115 mm in diameter. Care must be taken to avoid placing packers in sections of the hole that may have caved and become oversize. If the only suitable drilling method produces a larger hole, then backfilling should be considered. Backfilling is best suited to holes 150 mm in diameter and larger.

2.3.2 Borehole Wall Conditions

The condition of the borehole wall resulting from a given drilling method must be considered. Reasonably round, smooth walls are best for packer seals. Care must be taken to avoid areas of caving where angular breakouts may occur.

2.3.3 Drilling Fluids/Additives

The necessity and suitability of drilling fluids and additives should be considered. For example, if a drilling mud is felt to be required, can it be a biodegradable mud? If water sampling or hydraulic conductivity testing is required, can the mud be developed out of the system? Generally, if pressure monitoring is the only requirement, the use of mud does not have a significant effect (it may slow pressure measurement in some zones). Using a biodegradable mud should reduce such effects, but when water sampling is a requirement, biodegradable muds are rarely acceptable.

2.3.4 Core Hole vs. Rotary Hole

2.3.5 Guide Tube for MP Installation

Installing the MP casing through a steel guide tube such as driller's rods is prudent, particularly in areas of poor quality ground. This practice helps to ensure that the MP casing will reach the proper depth without problems due to caving of the hole. After the casing is in position, the packers are inflated in stages as the guide tube is removed. For MP casing with packers the guide tube must be flush-jointed on the inside with a minimum inside diameter of 75 mm.

2.4 Drillhole Logging

2.4.1 Purpose of Logging

Drillhole logging can be very helpful both for proper planning of the installation (packer locations, etc.) and for interpreting the results of pressure measurements. There are several types of logging procedures, each with its own contribution.

2.4.2 Caliper Logs

Caliper logs can be quite helpful in positioning casing packers where the drillhole has not collapsed or washed out to too large a diameter. Four or six arm calipers are preferred as they reduce the chances of missing a significant but narrow feature.

2.4.3 Geophysical Logs

Geophysical logs can contribute to the understanding of both the geology and drillhole condition. This information can help in the selection of monitoring zone locations and aid in the selection of preferable packer locations.

2.4.4 TV Logs

TV logs have proven valuable in selecting packer locations, particularly where proper positioning is very important (for example, due to a limited number of suitable locations).

2.4.5 Core

Examination of drill core can be very helpful, particularly in the absence of geophysical logs. As well as providing geologic information for the placement of monitoring zones, the condition of the core generally reflects the condition of the borehole wall. This information can in turn affect the positioning of casing packers.

3. Final Design

3.1 Positioning and Adjustment of Components

Final design takes place following completion of drilling. At this time it is not uncommon to modify the number and position of monitoring zones in response to variations in geology and/or drillhole condition.

3.2 Installation Log

Once the final design is decided upon, an installation log is completed giving a graphic illustration of the position of the various components in the well. Some last adjustments of position may be required based on the available selection of casing lengths, etc. It is important that this log show the position of every component to be used, including regular couplings, magnetic collars, etc.

3.3 Distribution of Forces

The loads (tensile and compressive) as well as pressure differentials imposed onto the MP System casing components during and following installation must be taken into consideration in order to prevent damage to MP System components. Under no circumstances should the load limits or pressure differentials exceed those recommended by Westbay (see Table 1). The expected loads and pressure differentials should be considered early on in any instrumentation program as these may dictate the use of particular MP casing component materials. Some of the major variables to be considered are: depth of drillhole, depth to water in the drillhole, high or low pressure zones, etc.

4. Installation (see MP Casing Installation Guide)

4.1 Equipment Requirements

4.1.1 Packer Inflation and Joint Testing Equipment (see packer inflation equipment manual)

The same tool is used for both joint hydraulic verification testing and for packer inflation, with only minor modifications to the assembly.

- items, set-up, surface testing

4.1.2 Backfilling Equipment

Backfilling equipment consists primarily of backfill materials, appropriately sized tremmie lines, funnels, sounding device, and drillhole collar clamping devices. A source of water for washing the backfill materials into place may also be desirable.

4.2 Layout and Documentation

As described previously, the casing installation log is prepared with the aid of geologic and geophysical logs and an understanding of the objectives of the program. The casing is then laid out on a rack in the same order as indicated on the log. The correct coupling is attached to the top end of each casing. All couplings must be kept free of grit. The layout is then rechecked for conformance to the log.

4.3 Hydraulic Testing of Joints and Couplings

These tests are performed to verify that no leaks are present in the assembled joints due to undetected faults, airborne particles or other foreign matter.

4.4 Installation with Packers in Open Holes

4.5 Installation with Packers Through Guide Tube

4.6 Packer Inflation Procedure

4.6.1 Packer Inflation and Documentation

4.6.2 Packer Inflation Curves

4.6.3 Troubleshooting Packer Inflation Equipment

4.7 Backfill Placement Procedure and Documentation

4.8 Verification Testing of Installed System and Documentation

- passive tests (head differences)
- active tests (slug testing, constant head testing). Must consider influence of packer stiffness, hydraulic conductivity contrast and borehole diameter to interpret results.

5. Fluid Pressure Monitoring with Electric Pressure Probe System (see manual).

5.1 Quality Control of Pressure Readings (see also Field Verification Plan)

5.1.1 Calibration of Pressure Probe

Probe output in response to change in pressure and/or temperature can be checked by applying a known pressure to the transducer inlet port using a deadweight tester or other precise source. The zero and gain of the transducer are adjusted on the probe circuit boards.

General practice at Westbay is to calibrate the output to be most linear at the temperature expected in the drillholes, and to record the output at a temperature 5 C degrees higher and 5 C degrees lower to give some idea of the effect of temperature changes.

Westbay probes are generally calibrated to have a combined non-linearity, hystresis and repeatability (CNLHR) less than or equal to 0.1 % of full scale (FS).

Probe transducer output may also be roughly checked by noting the response to change in elevation within an MP casing when the depth to water within the casing is known. This method is sensitive to the knowledge of the density of the water in the MP casing, the precision of the change in elevation and the precision of the depth to water.

5.1.2 Verification of Operation

As noted in the operating manual, the pressure inside the MP casing at each measurement port is recorded. If the displayed pressure changes and stabilizes properly when the probe is activated (see 5.7.4), this indicates that the probe is operating properly. In addition, once activated, the probe should resist moving in response to a gentle upward pull on the control cable.

If the pressure reading does not change when the probe is activated and the probe does resist moving when the cable is pulled, the face of the probe may not be properly sealed. Add water to the inside of the MP casing (or remove water from the MP casing). The pressure reading while the probe is activated should not change in response to the change in interior water level. If this is the case, deactivate the probe. The pressure reading inside the casing should now be different. Activate the probe once again to check the external pressure. If the pressure reading reacts to changes in interior water level whether activated or not, remove the probe and check the condition of the face seal and the strength of the backing shoe.

5.1.3 Verification of Location

The location of the electric pressure probe in a well may be approximately determined using a cable counter located over the well. Such counters generally have errors related to cable stretch and slippage. However, once the probe is located at known point in the well, such as on the bottom of the MP casing or at a magnetic location collar, counters are usually acceptable for measuring shorter movements from one point to another. Once the location arm has been released, by referring to a detailed log of the installation (indicating the location of all couplings in the well) the probe may be lifted the correct amount to locate in the first available coupling. Thereafter, lowering the probe into each coupling, noting the counter depth and referring to the log the pattern of variation of casing lengths can be used to verify the location of the probe.

If the water level inside the MP casing is the same from one set of measurements to the next, the pressure readings inside the casing may serve to confirm the location of the probe.

5.1.4 Stable Readings

In most cases the pressure reading obtained when the probe is activated is different from that inside the MP casing. Verifying that the readings are correct requires observation of the pressure as it changes from one value to the other.

Pressure Outside Lower Than Pressure Inside

When the pressure outside the casing is lower than that inside the display pressure should drop and then stabilize. The pressure may continue to drop in low-permeability zones where water may move from inside the casing to outside during activation, causing an increase in pressure in the monitoring zone. This excess pressure may take some time to dissipate. In this case the rate at which the pressure is dropping should continually decline as in a falling-head permeability test. If the probe is not properly sealed around the measurement port valve, water may be leaking from inside the casing to outside. In this case the water level observed inside the MP casing will drop and water pressures measured by the probe may rise.

Pressure Outside Higher Than Pressure Inside

Generally when the pressure outside the casing is higher than that inside the display pressure should increase and stabilize. The pressure may continue to rise in low-permeability zones where water may move from outside the casing to inside during activation, causing a decrease in pressure in the monitoring zone. The pressure in the zone may take some time to recover. In this case the rate at which the pressure is rising should continually decline (as in a rising-head permeability test). If the probe is not properly sealed around the measurement port valve, water may be leaking from outside the casing to inside. In this case the water level observed inside the MP casing will rise and water pressures measured by the probe may increase.

The value should not rise and then fall. When the probe is activated against a blank wall (such as in a regular coupling) water is trapped inside the face seal and the pressure observed by the transducer rises as the face seal is compressed. Once the pressure compensator moves, the pressure will fall somewhat and stabilize at a value intermediate to the inside casing pressure and the maximum value observed during activation. When in doubt this effect can be checked by raising the probe and holding it in a blank casing section, activating and observing the result (be careful not to activate in a coupling if the probe is not resting on the location arm). This effect is less obvious when the probe is not below the casing water level.

5.1.5 Field Calibration Check (see pressure probe manual)

5.1.6 Data Corroboration

5.1.7 Calculation of Relevant Piezometric Parameters

Piezometric Level Calculation using Direct Method (Figure 1)

Piezometric Level Calculation using Field Calibration Method (Figure 2)

5.1.8 Data Presentation

-head plots.

-pressure plots

5.2 Quality Control of Sampling Operations (See Electric Sampler Probe System Manual and Field Verification Plan).

5.3 Quality Control of Open/Close tool, used for pumping port operation (see Open/Close Tool Manual and Field Verification Plan)

6.0 MP System Monitoring Well Purging (see Figure 3 and Figure 4).

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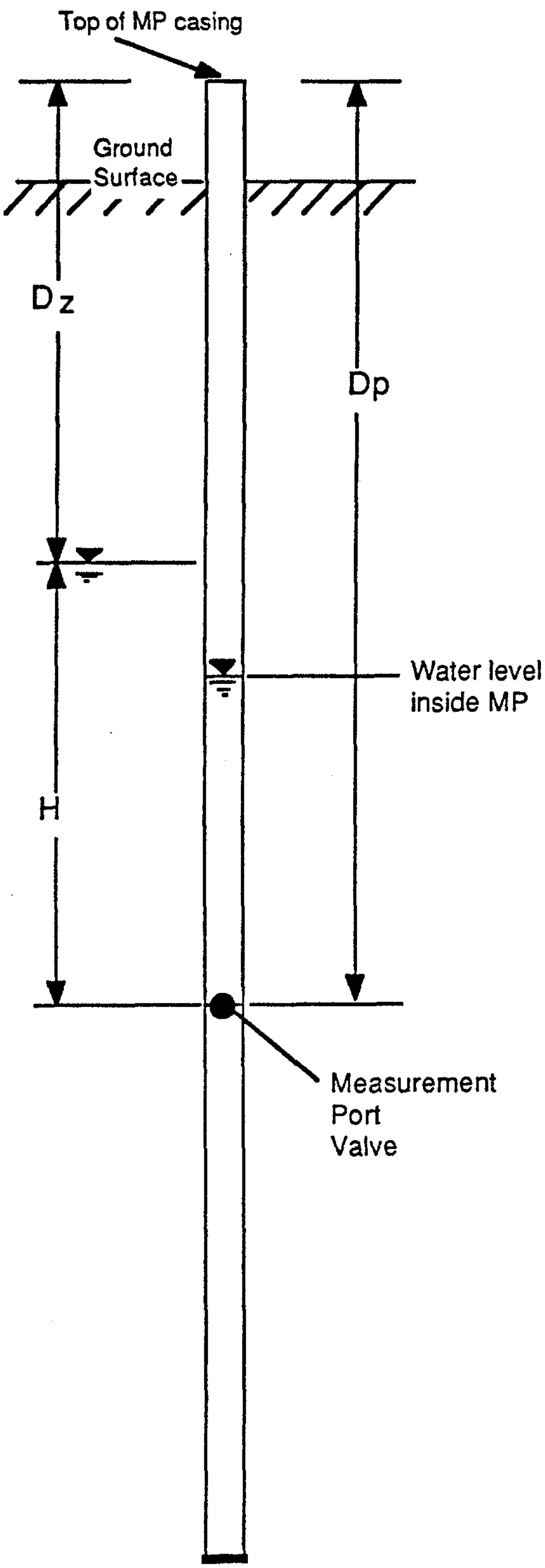
Figure 1
Piezometric Level Calculation Using Direct Method



Definition of Terms:

Dz = Depth to static water level for monitoring zone (below top of MP) (ft)

Dp = Depth of measurement port valve (below top of MP) (ft)

P = Outside pressure from field data (psi for pneumatic/ psia for electric)

P atm = Atmospheric pressure (psia)

H = Pressure head outside MP casing (ft)

w = weight of water with density of $1.0\ g/cm^3 = 0.4335$ psi/ft or 1.42 psi/m

Calculations:

$$H = \frac{P}{w} \qquad \text{for pneumatic probe} \quad (1a)$$

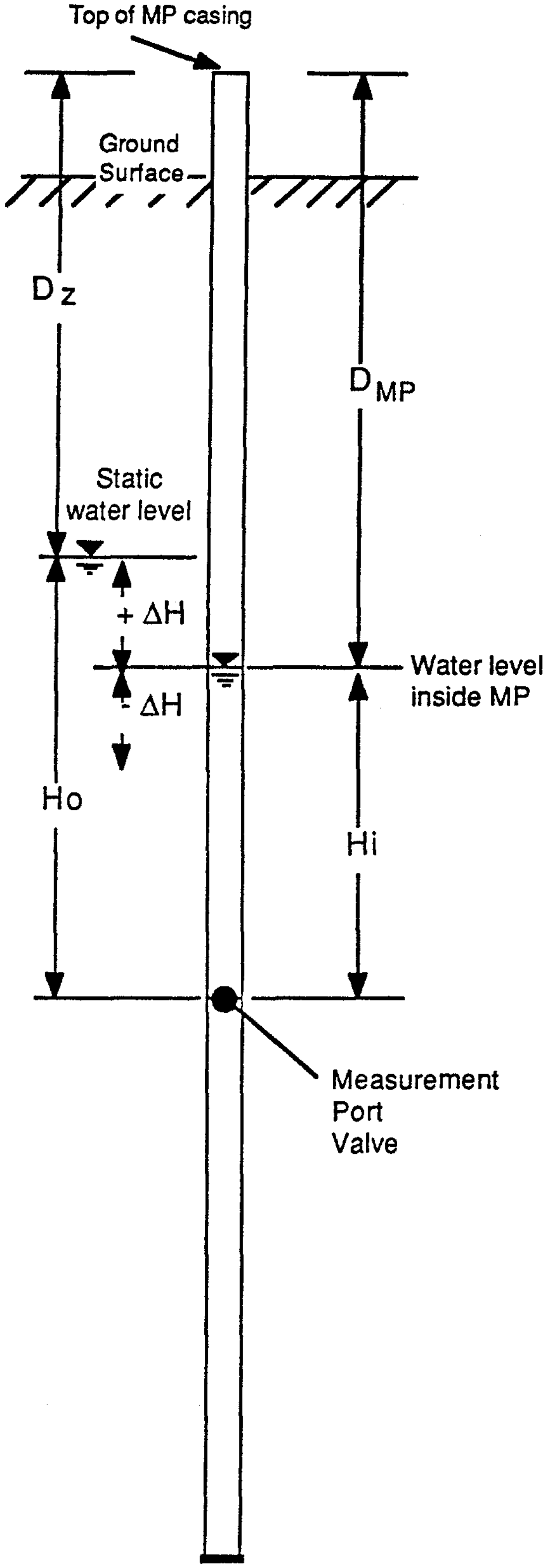
$$H = \frac{(P - P\ atm)}{w} \qquad \text{for electric probe} \quad (1b)$$

$$Dz = Dp - H \quad (2)$$

$$\text{Piezometric level} = \text{Elevation of top of MP} - Dz \quad (3)$$

Westbay Technical Note
Date: August 1, 1989

Figure 2:
Piezometric Level Calculation Using Field Calibration Method



Definition of Terms:

Dz = Depth to static water level for monitoring zone (below top of MP) (ft)

D_{MP} = Depth to water inside MP casing, from field data (below top of MP) (ft)

Po = Pressure reading outside MP casing (psia)

Pi = Pressure reading inside MP casing (psia)

P atm = Atmospheric pressure (psia)

Hi = Pressure head inside MP casing (ft)

Ho = Pressure head outside MP casing (ft)

ΔH = Pressure head difference between monitoring zone pressure head and casing pressure head as measured at measurement port valve (ft)

w = weight of water with density of 1.0 g/cm^3 = 0.4335 psi/ft or 1.42 psi/m

Calculations:

$$Hi = \frac{(P\,i - P\,atm)}{w} \tag{1}$$

$$Ho = \frac{(Po - P\,atm)}{w} \tag{2}$$

$$\Delta H = Ho - Hi = \frac{Po - Pi}{w} \tag{3}$$

$$Dz = D_{MP} - \Delta H \tag{4}$$

Piezometric level = Elevation of top of MP - Dz (5)

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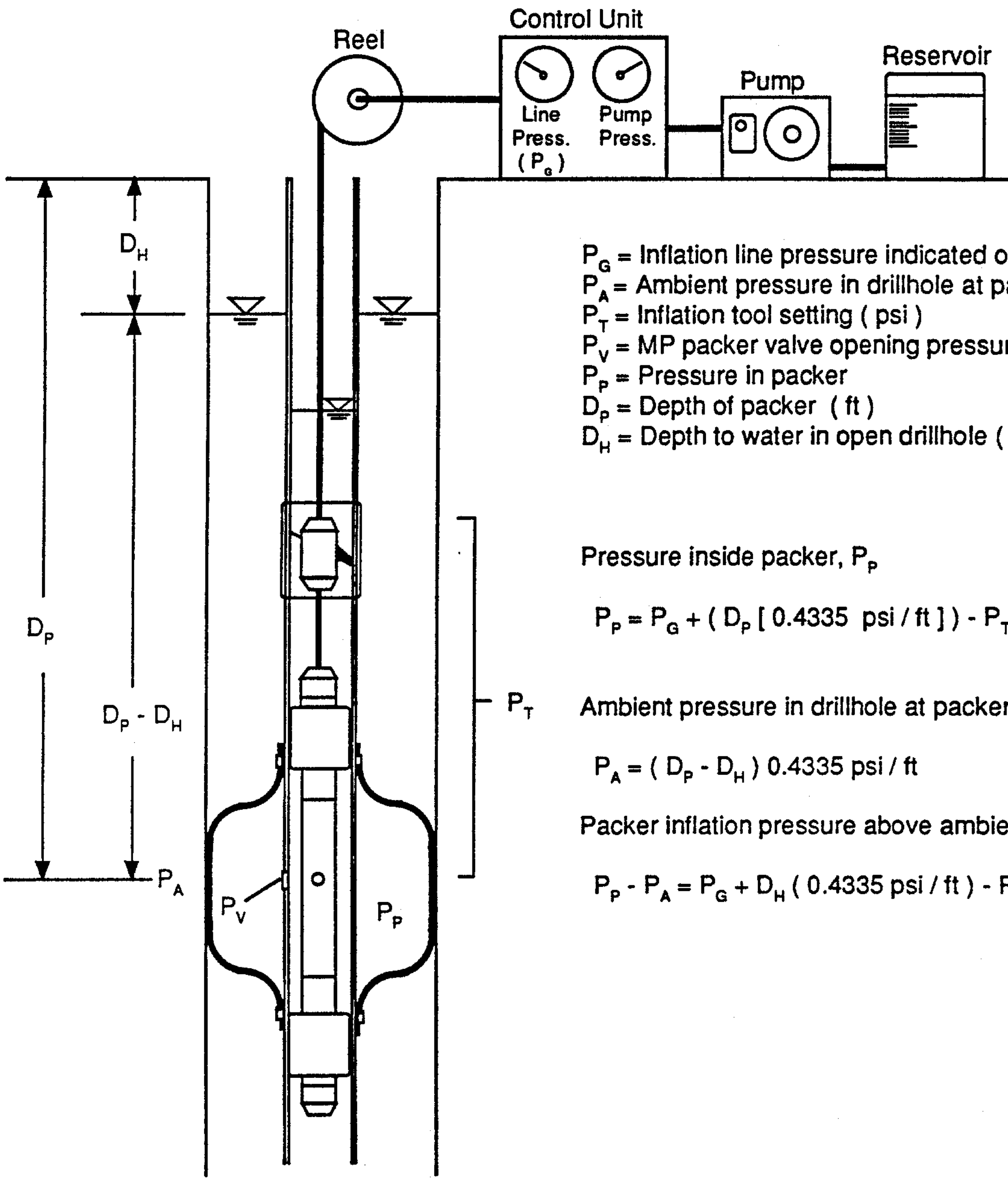
MP PACKER INFLATION PRESSURE CALCULATION



P_G = Inflation line pressure indicated on surface (psi)
P_A = Ambient pressure in drillhole at packer location (psi)
P_T = Inflation tool setting (psi)
P_V = MP packer valve opening pressure ~ 10 psi
P_P = Pressure in packer
D_P = Depth of packer (ft)
D_H = Depth to water in open drillhole (ft)

Pressure inside packer, P_P

$$P_P = P_G + (D_P [0.4335 \text{ psi / ft}]) - P_T - P_V$$

Ambient pressure in drillhole at packer location, P_A

$$P_A = (D_P - D_H) \, 0.4335 \text{ psi / ft}$$

Packer inflation pressure above ambient pressure in drillhole

$$P_P - P_A = P_G + D_H (0.4335 \text{ psi / ft}) - P_T - P_V$$

NOTE : For the standard 1.5 - inch MP system the packer inflation pressure should not exceed 80 - 100 psi and the injection volume should not exceed 1.3 gal U.S. (5.0 L)

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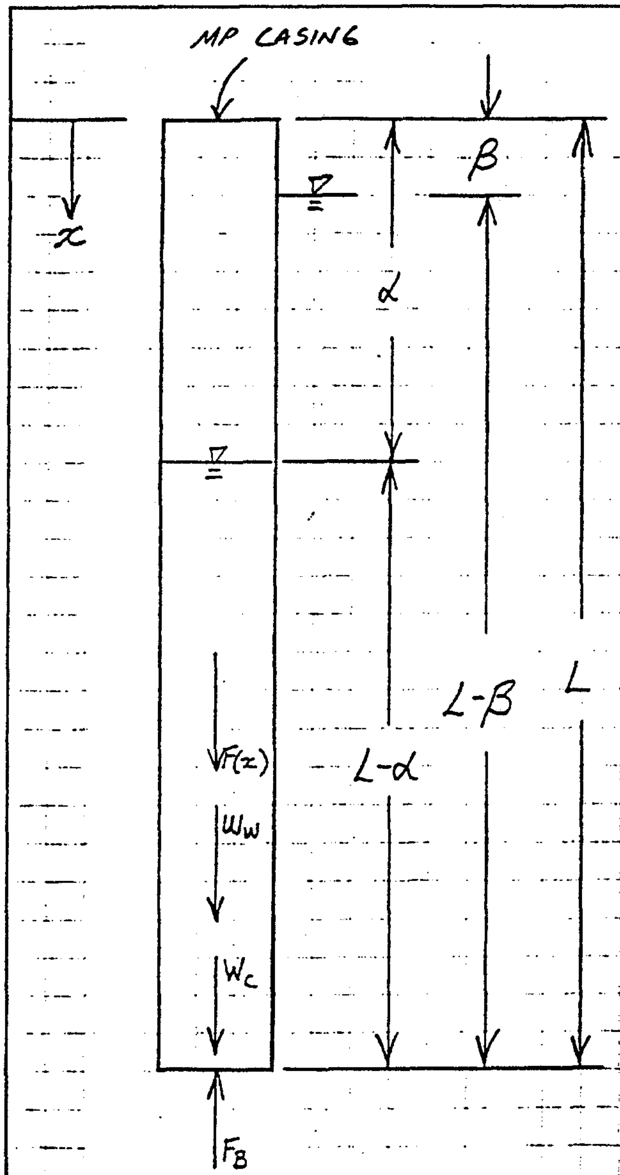
Subject: 1½" PLASTIC MP SYSTEM FORCE CALCULATIONS (MAXIMUM IN HOLE TEMPERATURE 30°C) Date: JULY 10, 1989

Project: Ref. No.:

Prepared by: ERIK REHTLANE Sheet: 1 of 3



FORCES ACTING ON MP CASING

F_B = BOUYANCY FORCE $= \pi r_{O.D.}^2 \gamma_W (L-\beta)$

$F(x)$ = RESULTANT FORCE AT POINT x (COMPRESSION IS POSITIVE, TENSION IS NEGATIVE)

W_W = WEIGHT OF WATER $= \pi r_{I.D.}^2 \gamma_W (L-\alpha)$

W_C = DRY WEIGHT OF CASING $= \pi (r_{O.D.}^2 - r_{I.D.}^2) \gamma_C (L-x)$

VARIABLES

L = LENGTH OF MP CASING

β = DEPTH TO WATER IN OPEN DRILLHOLE

α = DEPTH TO WATER INSIDE MP CASING

CONSTANTS

γ_W = UNIT WEIGHT OF WATER

γ_C = UNIT DRY WEIGHT OF MP CASING.

$r_{I.D.}$ = RADIUS OF INTERIOR OF MP CASING

$r_{O.D.}$ = RADIUS OF EXTERIOR OF MP CASING

ASSUMPTIONS

1) DENSITY OF WATER INSIDE AND OUTSIDE OF MP CASING IS 1.0 gm/cc
2) FRICTION EFFECTS ARE NOT CONSIDERED
3) PLASTIC MP CASING ONLY IS CONSIDERED. PACKERS AND COUPLING EFFECTS ON THE DRY WEIGHT OF THE MP CASING IS NOT CONSIDERED
4) BUCKLING IS NON-CRITICAL FOR 3" (74mm) AND 4" (100mm) HOLES
5) $\alpha > \beta$, SO AS TO NOT PREMATURELY INFLATE PACKERS.
6) HIGH PRESSURE GRADIENTS WILL NOT BE ENCOUNTERED IN THE FORMATION

507 East Third Street, North Vancouver, British Columbia, Canada V7L 1G4, Telephone: 604-984-4215, Telex: 04-352606

$$\Sigma F = 0 = -W_W - W_C + F_B - F(x)$$

$$\therefore F(x) = \pi r_{O.D.}^2 \gamma_W (L-\beta) - [\pi r_{I.D.}^2 \gamma_W (L-\alpha)] - [\pi (r_{O.D.}^2 - r_{I.D.}^2) \gamma_c (L-x)]$$

$r_{O.D.} = 0.07917$ ft $= 0.02413$ m
$r_{I.D.} = 0.0615$ ft $= 0.01874$ m

$\gamma_W = 62.4$ lb/ft³ $= 9.803 \times 10^3$ N/m³
$\gamma_C = 86.1$ lb/ft³ $= 1.3526 \times 10^4$ N/m³

$$\therefore F(x) = -0.1928L - 1.2286\beta + 0.7414\alpha + 0.68x \quad \text{(ENGLISH UNITS)}$$

INSTALLATION FORCE CALCULATION STEPS

1) CALCULATE TENSION ON MP CASING AT TOP OF HOLE PRIOR TO REACHING GROUNDWATER LEVEL.
   $F_{TENSION} = 0.68$ lb/ft (9.92 N/m) x DEPTH TO WATER IN DRILLHOLE
   IF TENSION LIMIT IS EXCEEDED HYBRID PLASTIC/STAINLESS STEEL OR ALL STAINLESS STEEL MP COMPONENTS MUST BE USED. THE CALCULATED TENSION WILL ALSO INDICATE WHETHER THE MP CASING MAY BE LOWERED BY HAND OR WITH A CRANE.

2) CONSIDER FULLY INSTALLED POSITION, FLOATING CONDITION. CALCULATE THE DEPTH TO WATER INSIDE THE MP CASING FOR NEUTRAL BOUYANCY. CALCULATE THE COMPRESSION LOAD ON THE END CAP. CALCULATE THE PRESSURE DIFFERENTIAL CONDITION (EXTERIOR OVER INTERIOR)

   A. TENSION (MAXIMUM) = 400 lbs = 1.779×10^3 N

   B. COMPRESSION (MAXIMUM) = 800 lbs = 3.558×10^3 N

   C. PRESSURE DIFFERENTIAL, EXTERIOR OVER INTERIOR (MAXIMUM) = 200 lb/in² = 1.379×10^3 Pa (N/m²)

   IF ANY LIMITS ARE EXCEEDED, ADJUST α SUCH THAT THE CRITERIA ABOVE ARE MET. IF THIS CAN NOT BE DONE, HYBRID PLASTIC/STAINLESS STEEL OR ALL STAINLESS STEEL MP COMPONENTS MUST BE USED.

EXAMPLE = $L = 1640$ ft (500 m)
$\beta = 30$ ft (9 m)

1) FULLY INSTALLED, NEUTRAL BOUYANCY, $F(x) = 0$, $x = 0$
FIND α
$F(x) = -0.1928L - 1.2286\beta + 0.7414\alpha + 0.68x$
$0 = -0.1928(1640) - 1.2286(30) + 0.7414\alpha + 0.68(0)$
$\alpha = 476.2$ ft

2) CALCULATE COMPRESSION FORCE ON BOTTOM CAP
$x = 1640$, $\alpha = 476.2$ ft
$F(x) = -0.1928L - 1.2286\beta + 0.7414\alpha + 0.68x$
$F(x) = 1{,}115.2$ lbs
∴ COMPRESSION LOAD LIMIT IS EXCEEDED

3) DIFFERENTIAL PRESSURE (EXTERIOR - INTERIOR) CALCULATION
476.2 ft - 30 ft = 446.2 ft OR 193.4 psi
α MUST BE ADJUSTED TO MAKE COMPRESSION LOAD ACCEPTABLE

4) FIND α WHEN $F(x) = 800$, $x = 1640$, $\beta = 30$, $L = 1640$

$\alpha = 51.05$ ft (NOTE = THIS IS CLOSE TO MAXIMUM DEPTH PLASTIC MP CASING MAY BE LOWERED $L = 1672'$, $F(x) = 800$, $x = L$, $\beta = \alpha$)

5) FIND $F(x)$ WHEN $x = 0$, $\beta = 30$, $L = 1640$, $\alpha = 51.0$ ft.

$F(x) = -315.2$ lbs (TENSION)

6) FIND DEPTH AT WHICH WATER MUST BE ADDED TO INSIDE OF MP CASING TO PREVENT EXCEEDING COMPRESSION LOAD LIMIT.

MUST SATISFY BOTH $F(x) = 0$, $x = 0$
$F(x) = 750$ lbs, $x = L$

(A) $0 = -0.1928L - 1.2286(30) + 0.7414\alpha$
$36.858 = -0.1928L + 0.7414\alpha$

(B) $713.142 = 0.4872L + 0.7414\alpha$

(B) - (A) = $676.284 = 0.68L$ ∴ $L = 994.5'$, $\alpha = 308.4'$

∴ CRANE WILL BE NEEDED FOR LOWERING MP CASING BELOW 995 FT (303 m) AS TENSION AT SURFACE WILL BE INCREASED FROM THIS POINT TO A FINAL TENSION OF 315 lbs WHEN ALL THE CASING HAS BEEN LOWERED.

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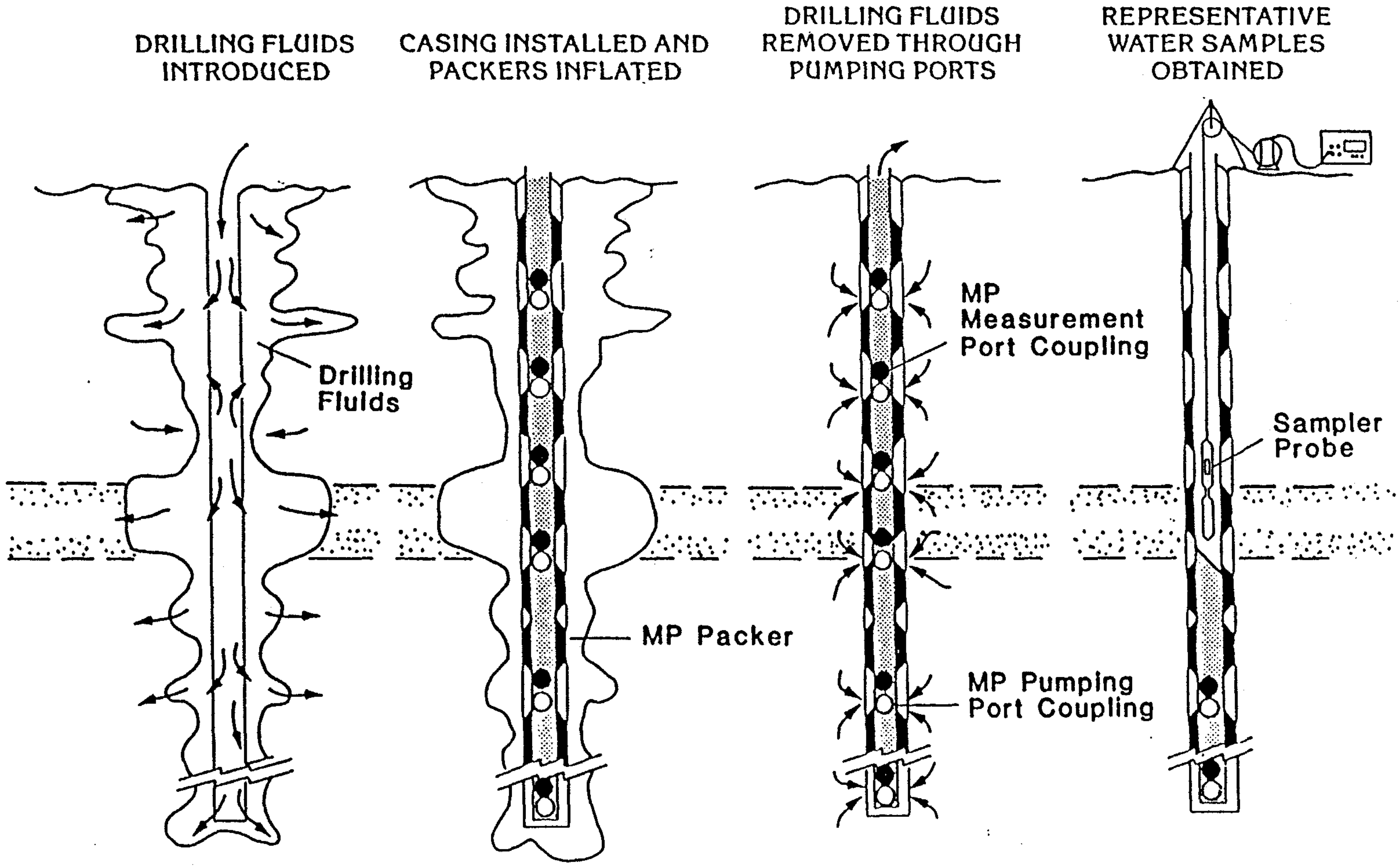
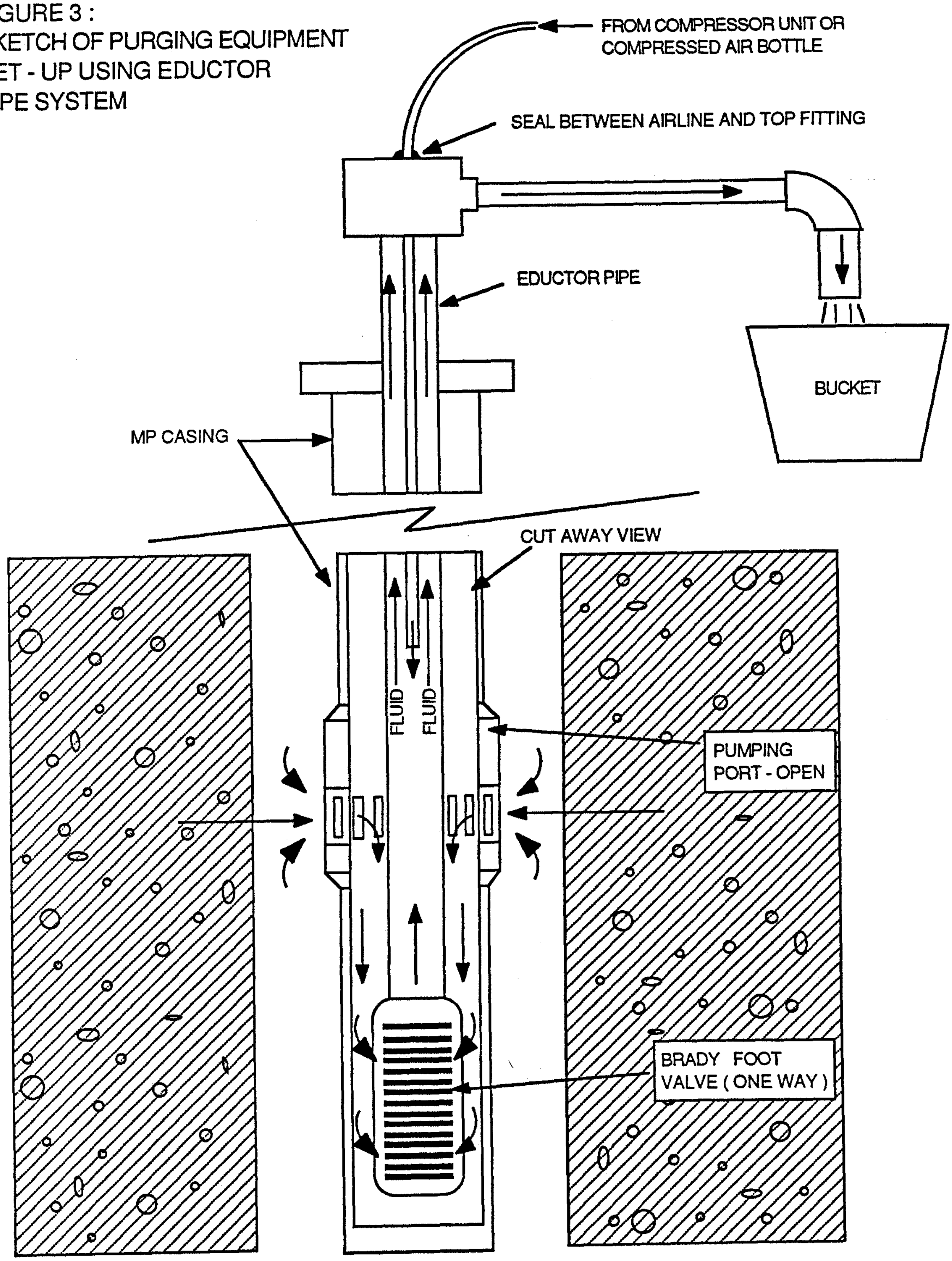


FIGURE 3 :
SKETCH OF PURGING EQUIPMENT
SET - UP USING EDUCTOR
PIPE SYSTEM



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NOTE : DO NOT ALLOW WATER LEVEL IN THE MP TO APPROCH PUMPING PORT SO AS TO AVOID INTRODUCING AIR INTO FORMATION.

FIGURE 4 :
SKETCH OF PURGING EQUIPMENT
SET - UP USING SUCTION
PUMP

NOT TO SCALE

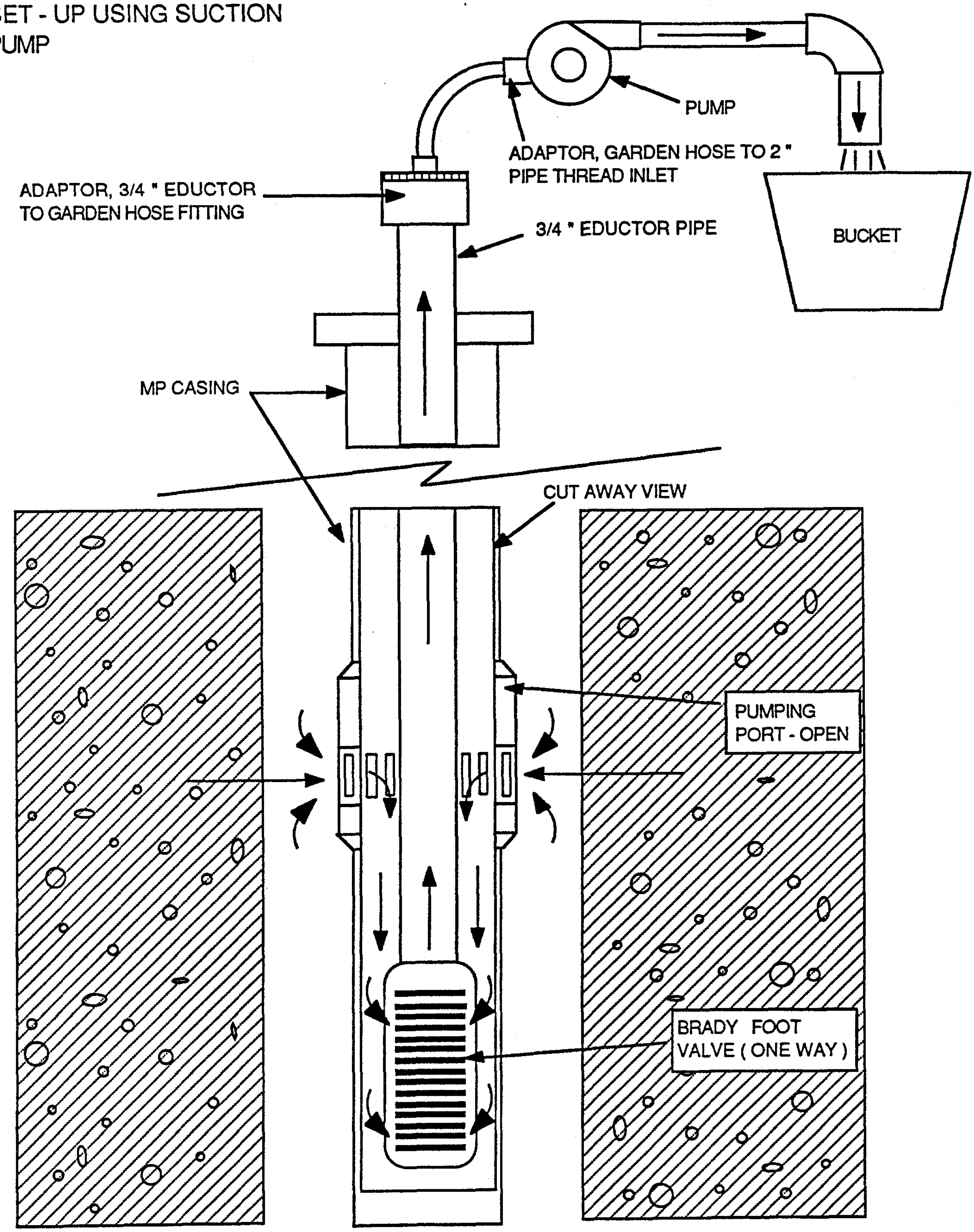

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Table 1

Strength and Differential Pressure Specifications for
MP System casings and Couplings, 38mm(1.5in) I.D.

		Plastic System	Plastic-Steel System		Stainless Steel System
			Standard	High Performance	
Tensile Strength (yield)	kN (lbs)	3.6 (800)	12.6 (2800)	12.6 (2800)	73 (16,000)
Operating Tensile Load	kN (lbs)	1.8 (400)	6.3 (1400)	6.3 (1400)	36 (8000)
Operating Compression * Load	kN (lbs)	3.6 (800)	6.3 (1400)	6.3 (1400)	36 (8000)
Maximum Differential Operating Pressure (inside over outside)	kPa (psi)	700 (100)	700 (100)	2100 (300)	2100 (300)
Maximum Differential Operating Pressure* (outside over inside)	kPa (psi)	1000 (145)	1000 (145)	2800 (400)	4200 (600)
Maximum Differential Pressure (outside over inside) critical component	kPa (psi)	1400 (200) F.S.=2.0 pumping port	5600 (800) casing	5600 (800) casing	10,000 (1450) packer

11JULY, 1989

*Unfractured rock, 76mm (3in) drillhole diameter.

Table 2

Operating Temperature and Differential Pressure Specifications
for MP System Packers, 38 mm (1.5 in) I.D.

	Standard Element on Plastic Casing	Reinforced Element on Plastic Casing	Standard Element on Stainless Steel Casing	Reinforced Element on Stainless Steel Casing	Reinforced Element, Deflatable on Stainless Steel Casing	Mechanical Element on Stainless Steel Casing	Nitrile/ Steel Element on Stainless Steel Casing
Maximum Operating Temperature (deg C)	30	30 70*	30 70*	30 70*	30 70*	30 70*	95^
Compliance	soft	moderately stiff	soft	moderately stiff	soft	very stiff	stiff
Maximum Operating Differential Pressure** kPa (psi) (across packer element)	700 (100)	1400 (200)	700 (100)	1400 (200)	3100 (450)	4200 (600)	7000 (1000)
Maximum Operating Differential Pressure kPa (psi) (inside over outside)	700 (100)	700 (100)	700 (100)	700 (100)	3100 (450)	4200 (600)	3500 (500)
Maximum Operating Differential Pressure kPa (psi) (outside over inside)	700 (100)	1400 (200)	700 (100)	1400 (200)	3100 (450)	10,000 (1450)	7000 (1000)
Drillhole Diameter mm (in)	76 3.0	76 3.0	76 3.0	76 3.0	100 4.0	100 4.0	76 3.0

05April1989

^ With steel reinforced Nitrile element
* With Nitrile or other type of element available
** Unfractured rock

MP System Installation Methods

Tremmie Backfill with Guidetube

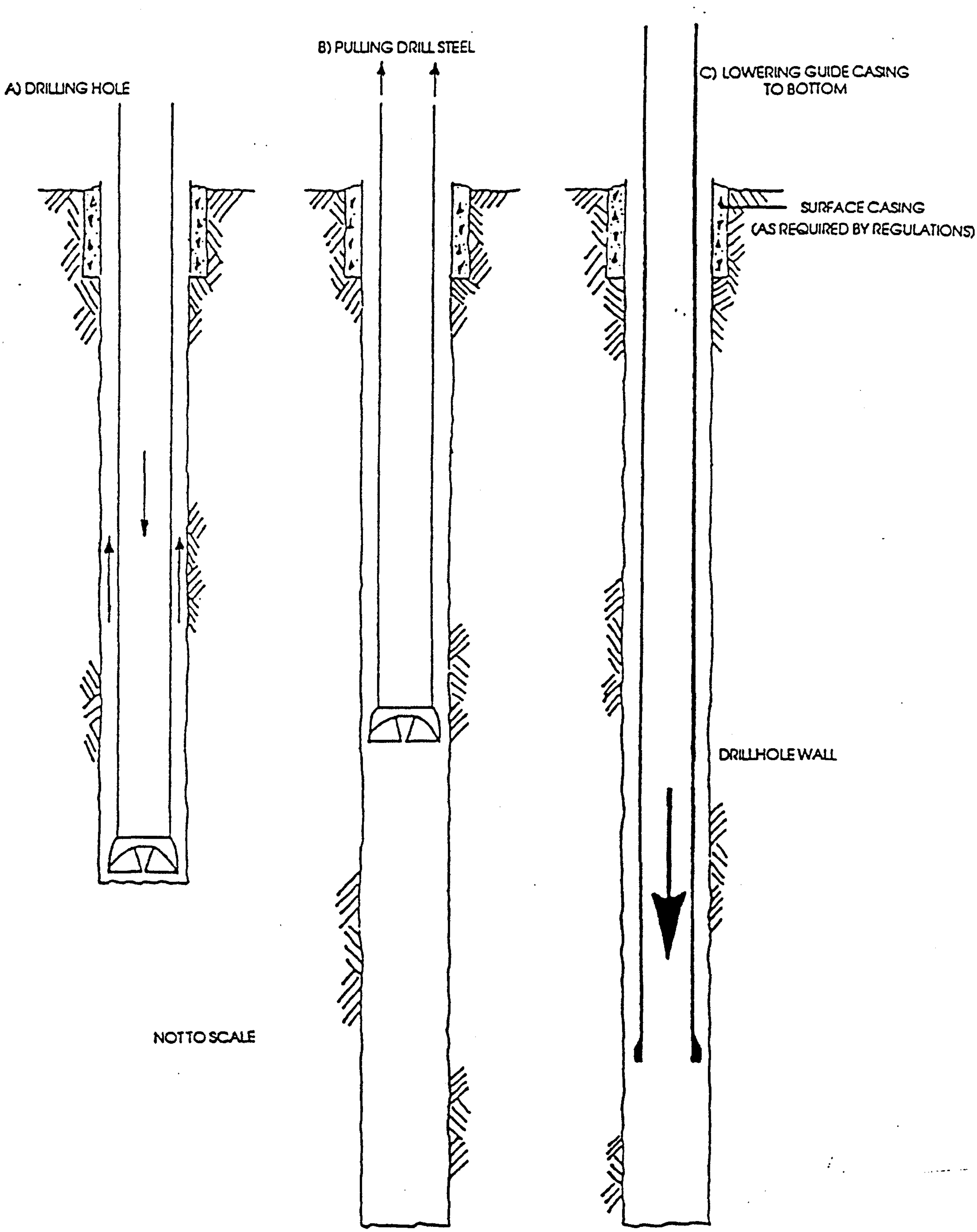
by

Westbay Instruments Inc.

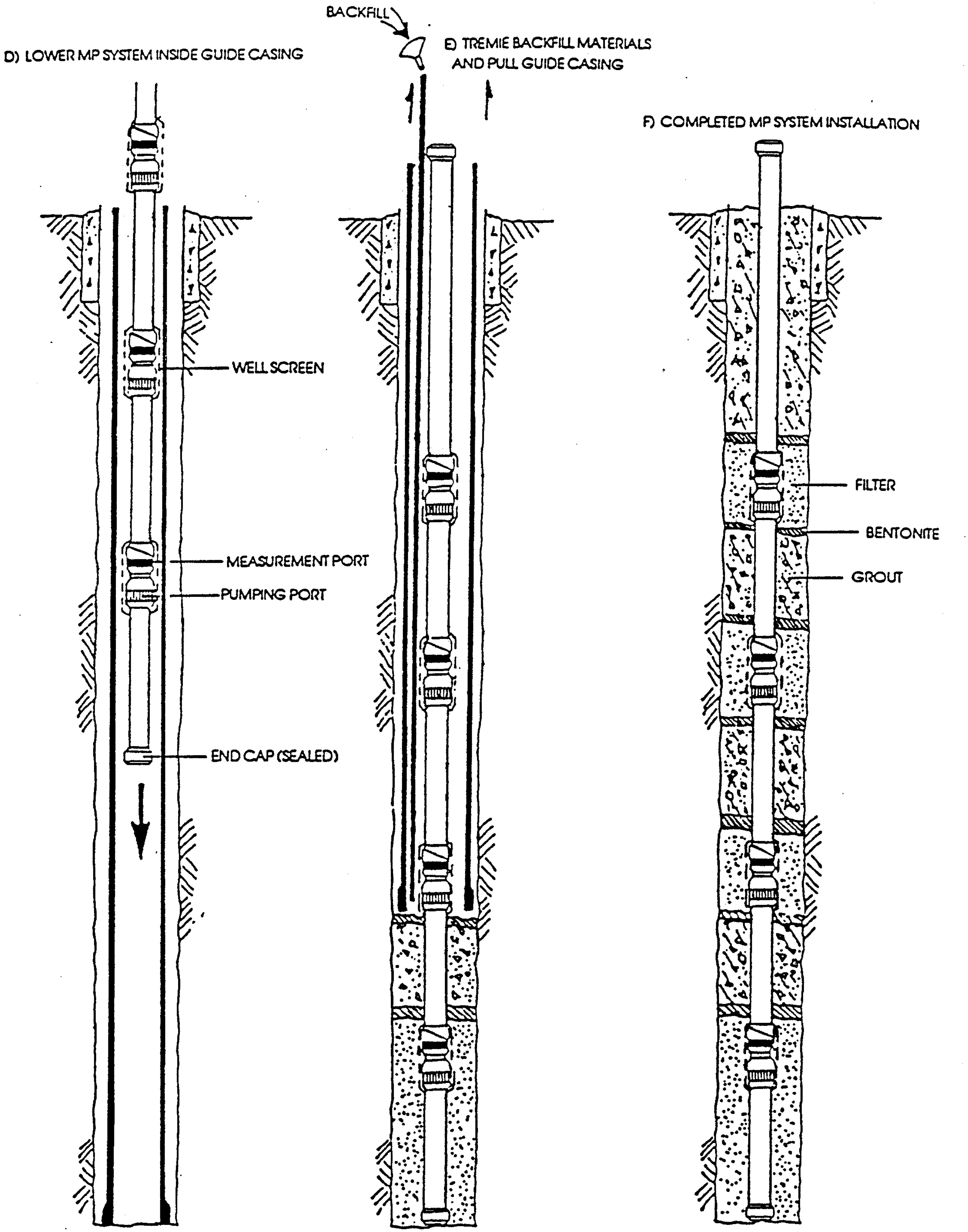
Contents

MR 01/07/89

INSTALLATION OF MP SYSTEM IN OPEN DRILLHOLE WITH BACKFILLED SEALS



MR 01.07.89



D) LOWER MP SYSTEM INSIDE GUIDE CASING
BACKFILL
E) TREMIE BACKFILL MATERIALS AND PULL GUIDE CASING
F) COMPLETED MP SYSTEM INSTALLATION
WELL SCREEN
MEASUREMENT PORT
PUMPING PORT
END CAP (SEALED)
FILTER
BENTONITE
GROUT

NOT TO SCALE

MP System Installation Methods

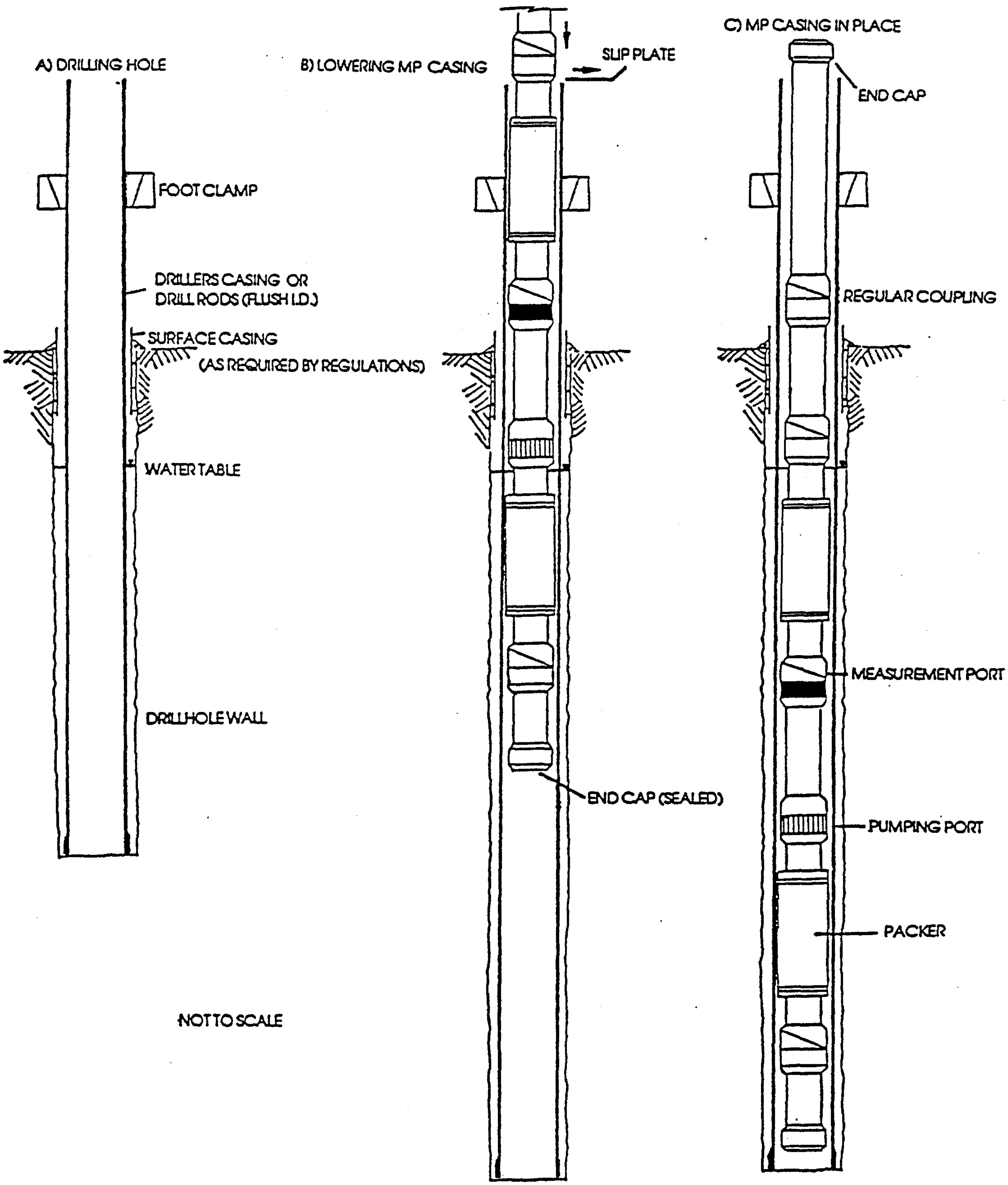
Guide Tube with Packers

by

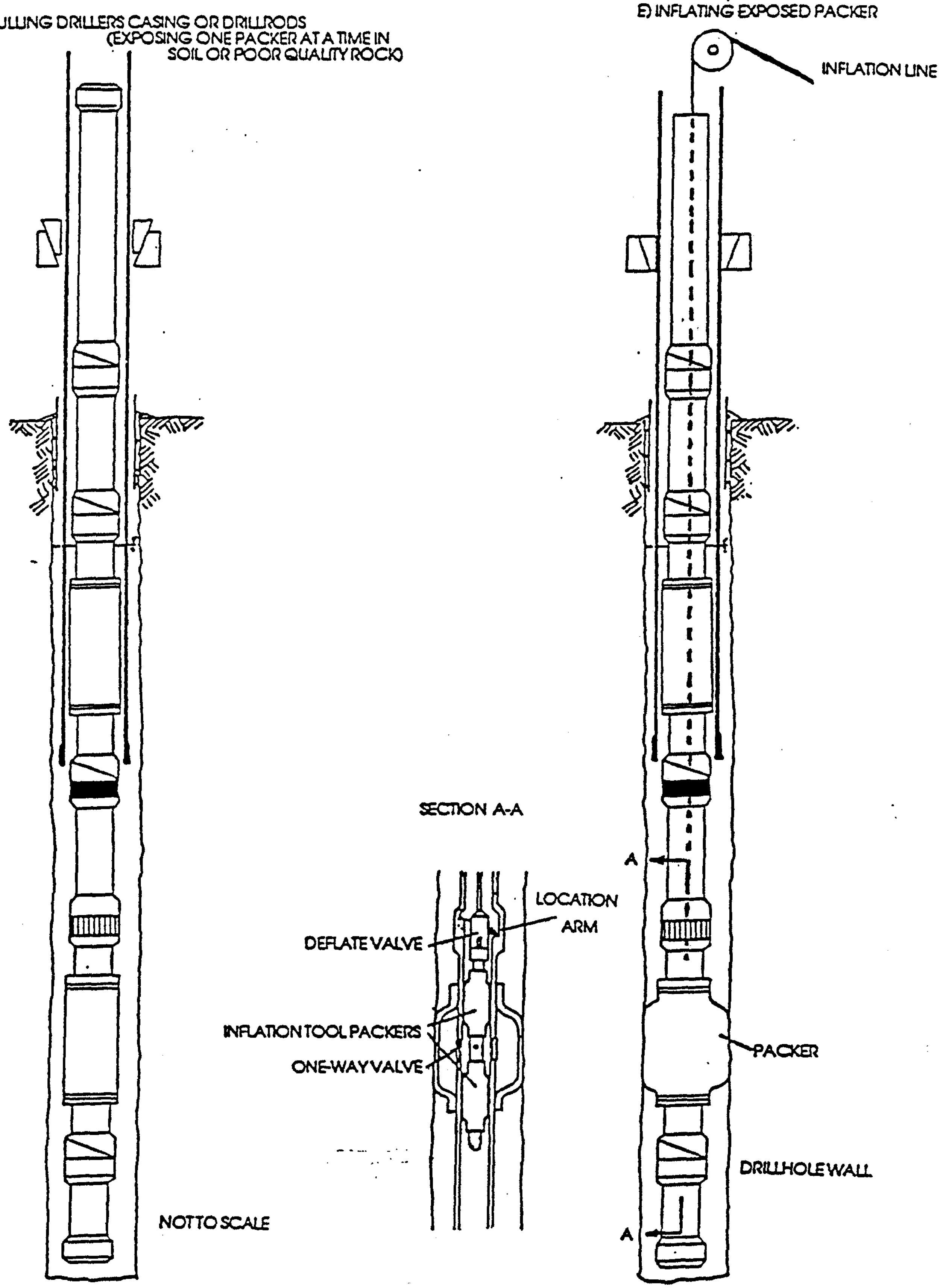
Westbay Instruments Inc.

Contents

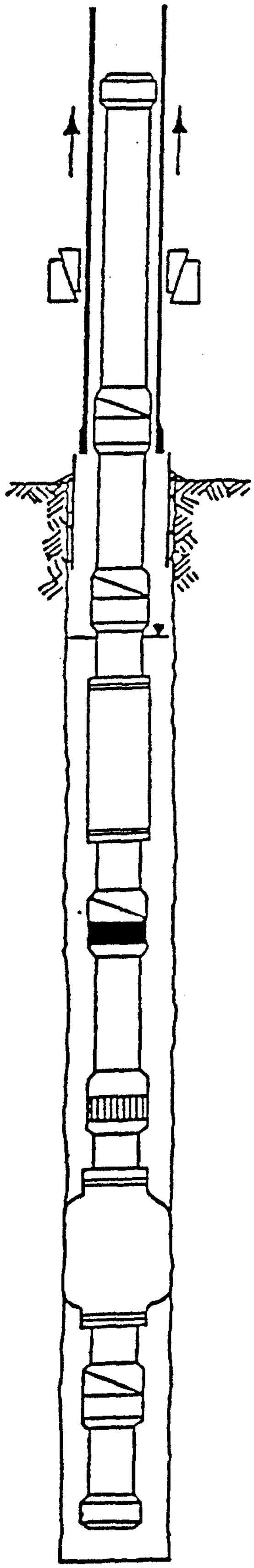
INSTALLATION OF MP SYSTEM THROUGH DRILLERS CASING OR RODS



MR 01.07.89

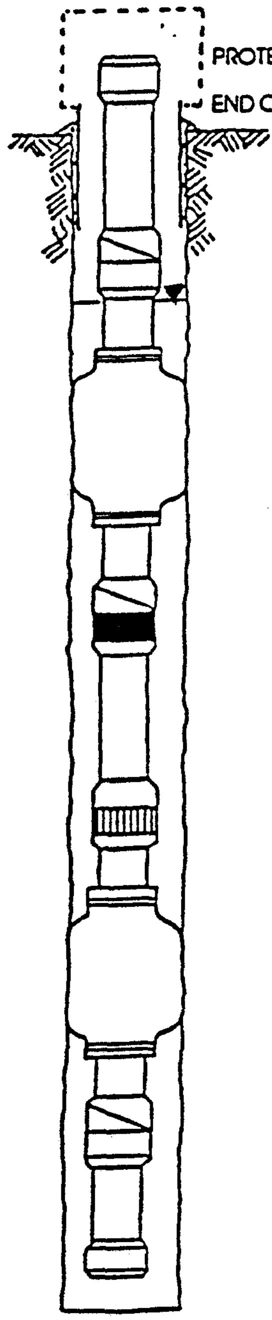

D) PULLING DRILLERS CASING OR DRILLRODS
(EXPOSING ONE PACKER AT A TIME IN
SOIL OR POOR QUALITY ROCK)
NOT TO SCALE
E) INFLATING EXPOSED PACKER
INFLATION LINE
A
A
PACKER
DRILLHOLE WALL
SECTION A-A
LOCATION
ARM
DEFLATE VALVE
INFLATION TOOL PACKERS
ONE-WAY VALVE

F) REMOVING DRILLERS REMAINING CASING OR DRILLRODS



NOT TO SCALE

G) PACKER INFLATION COMPLETED



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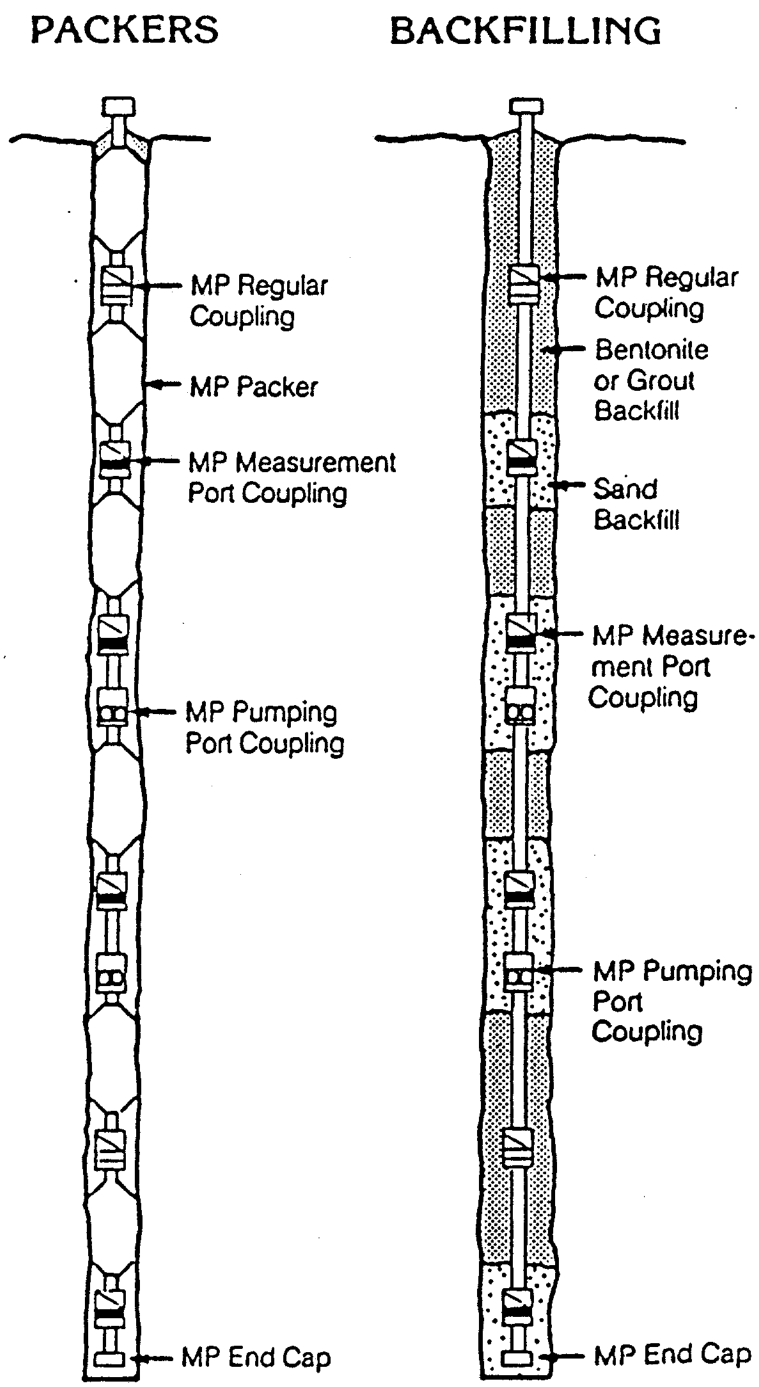
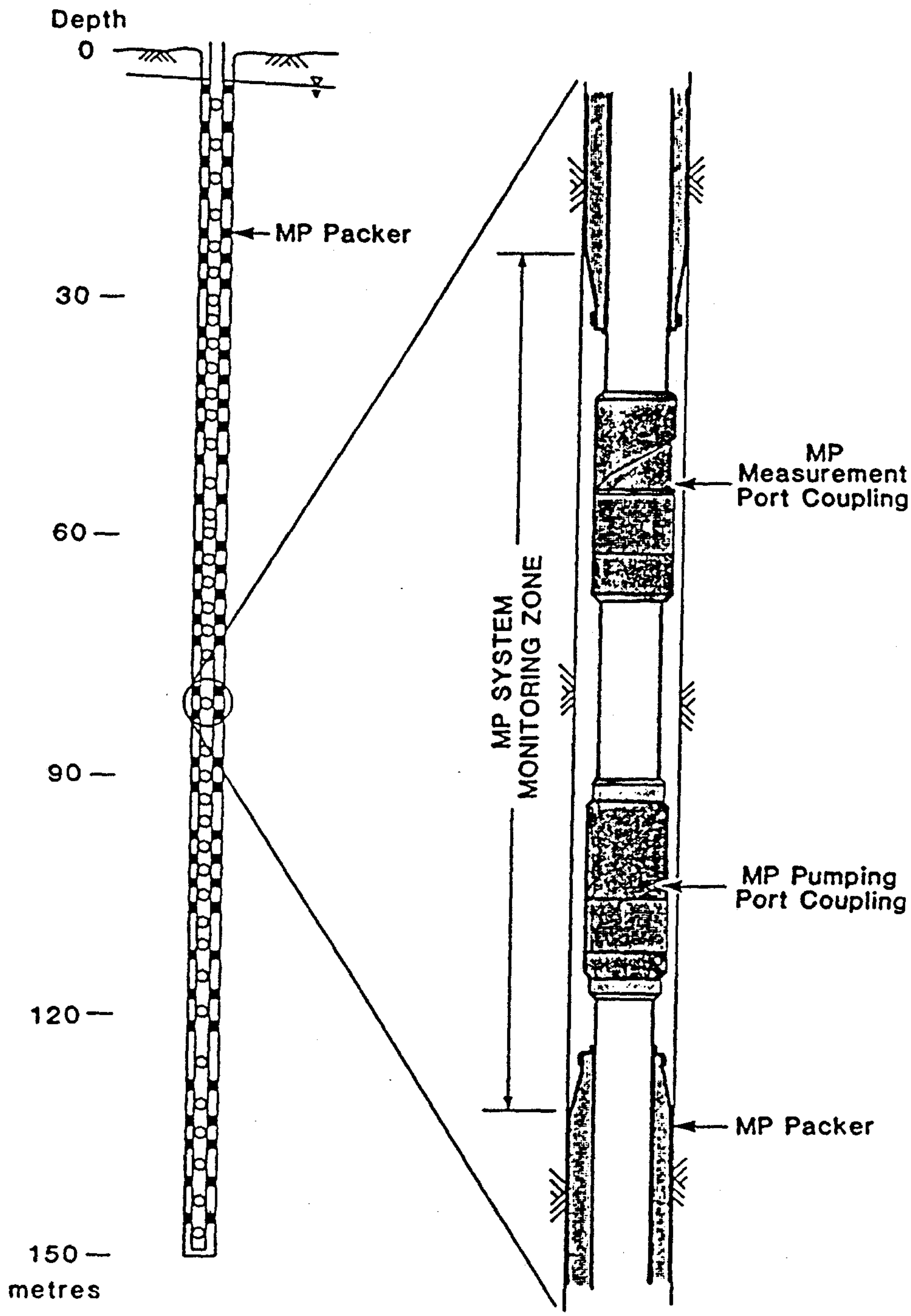


THE MP SYSTEM WITH PACKERS



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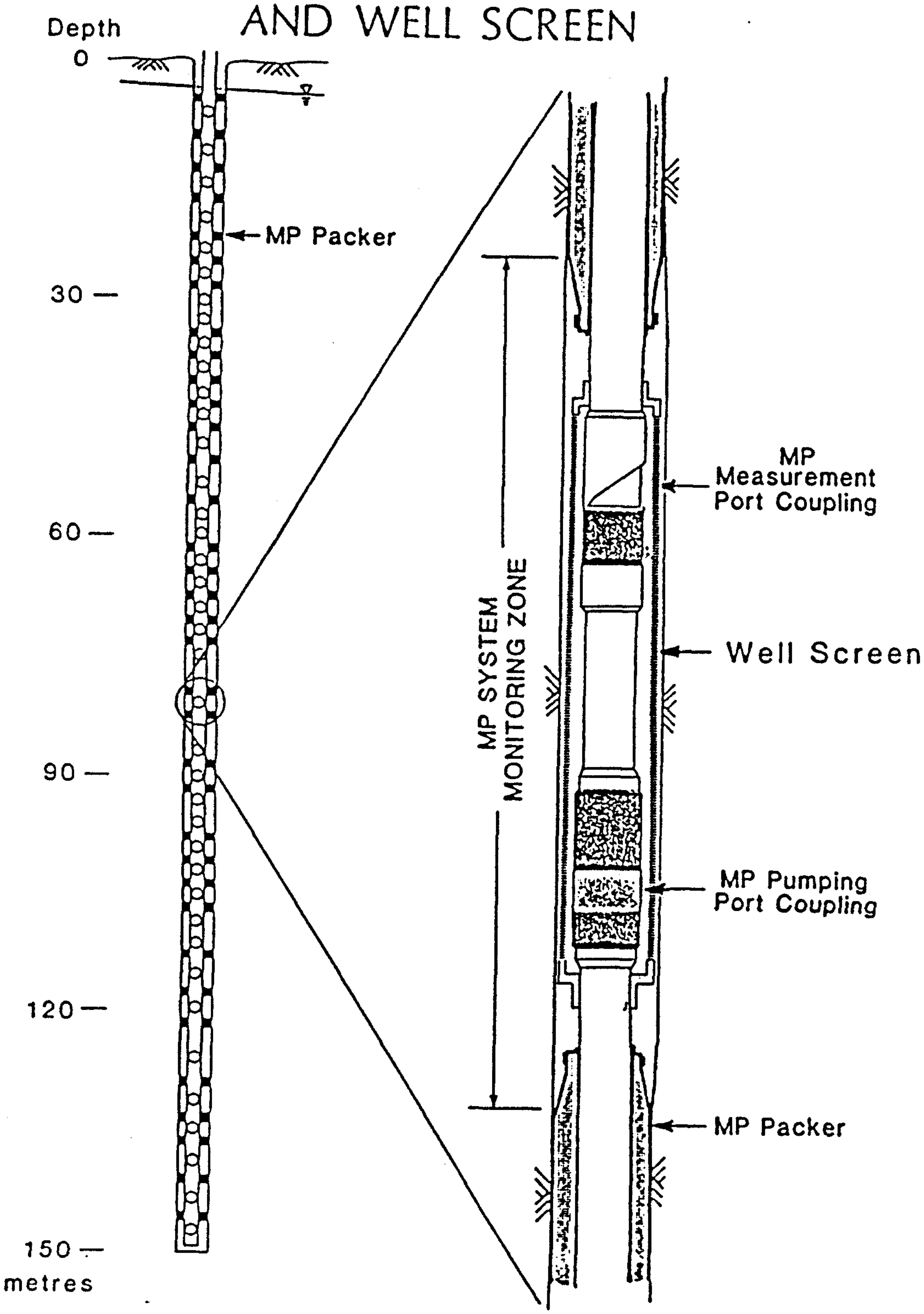
THE MP SYSTEM WITH PACKERS AND WELL SCREEN



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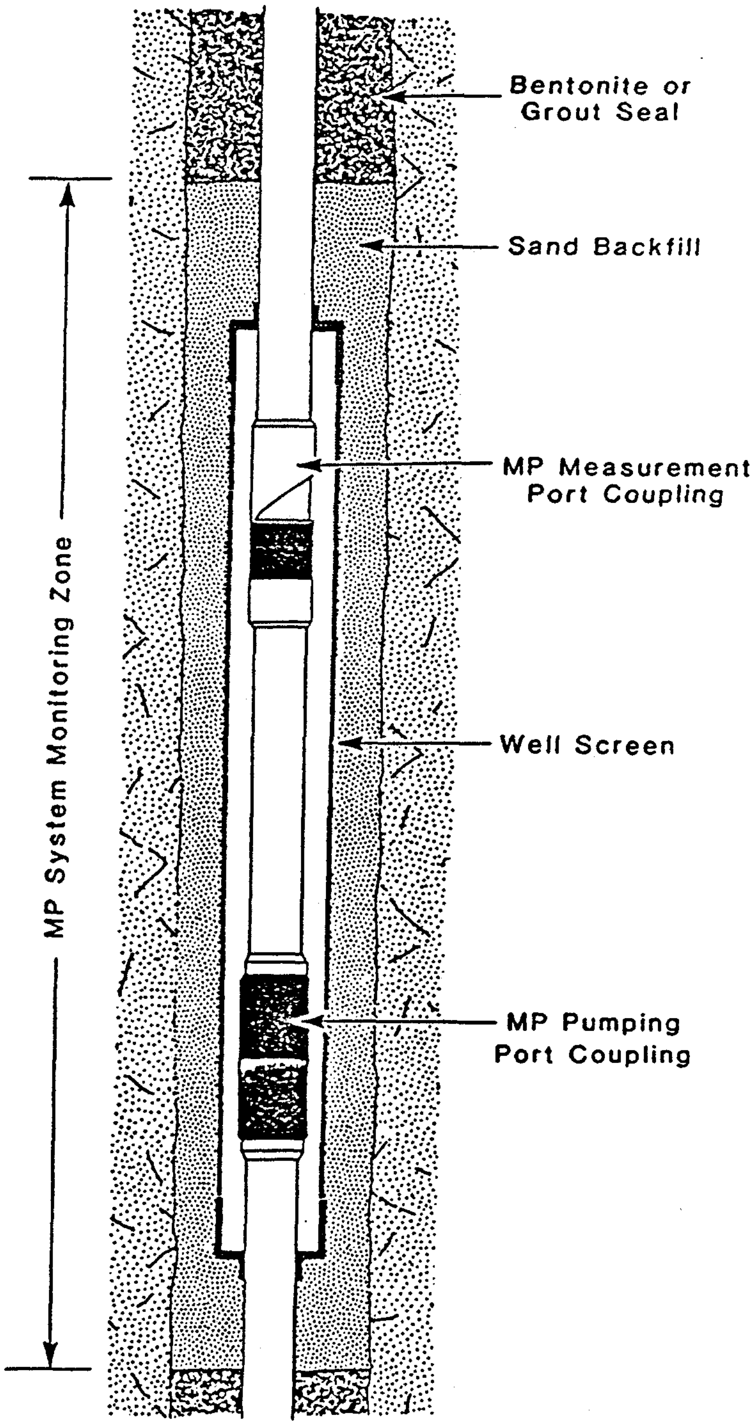
THE MP SYSTEM
WITH BACKFILL AND WELL SCREEN



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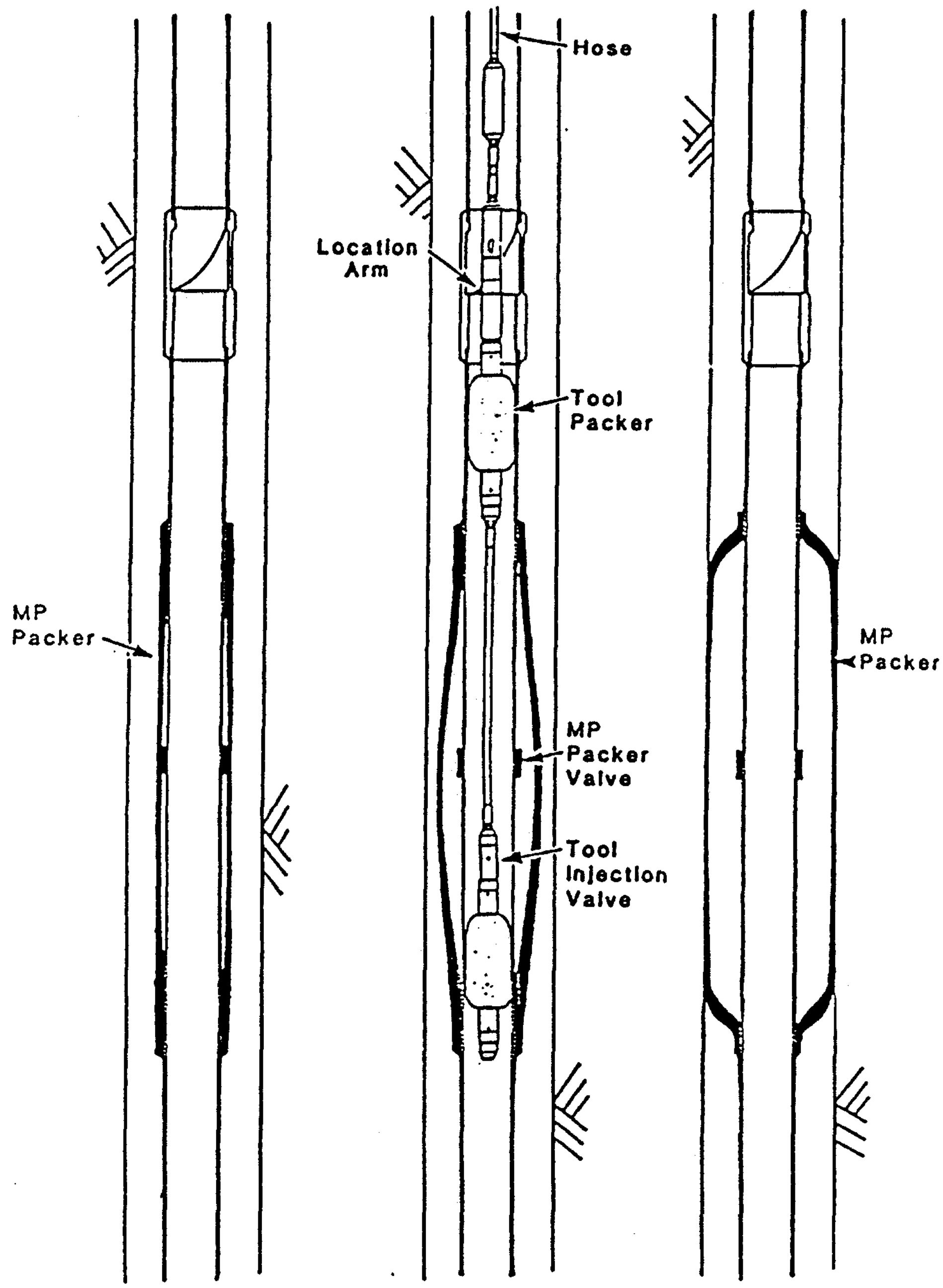
STANDARD PACKER INFLATION

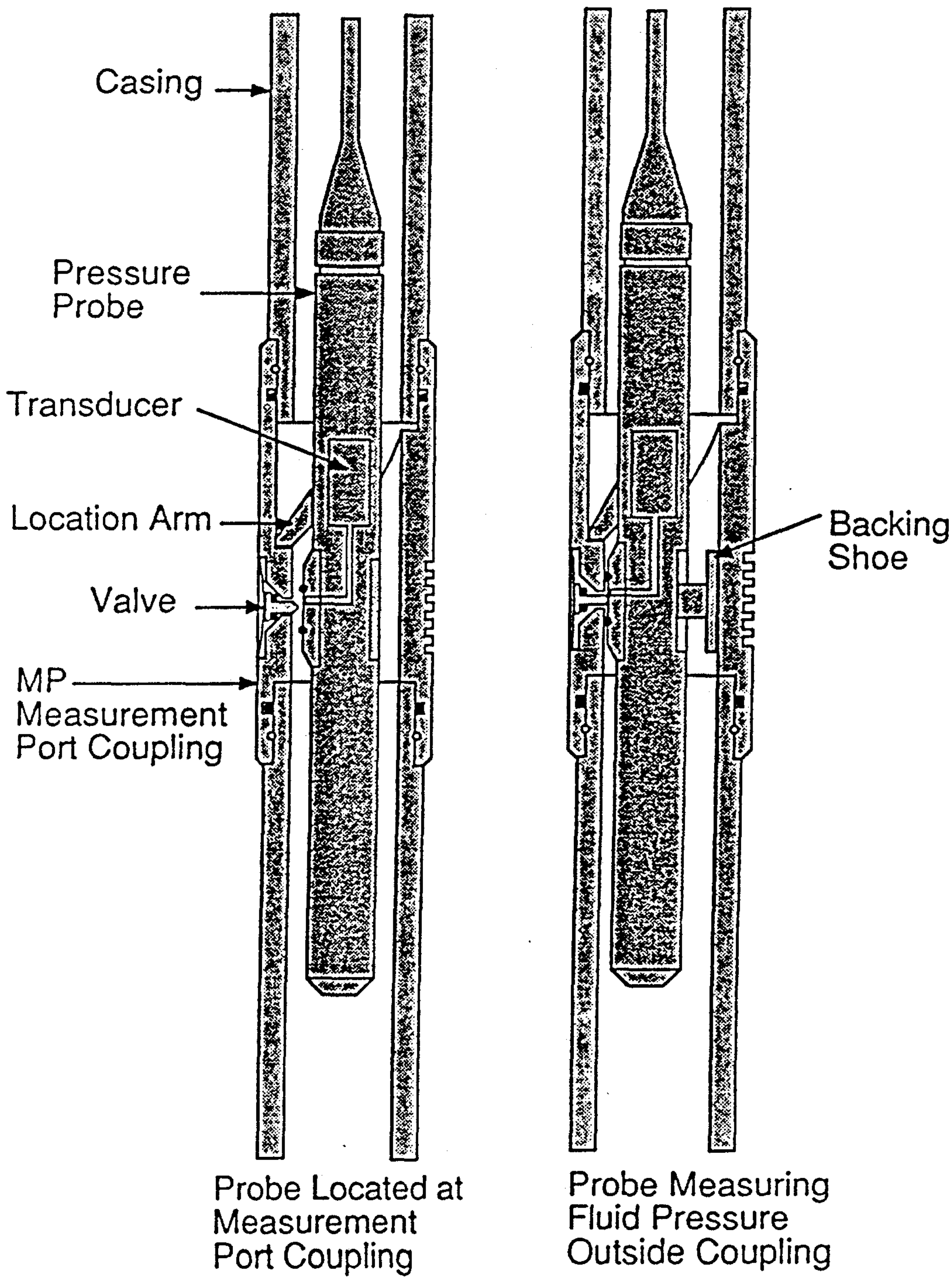


1. Packer as installed

2. Inflation Tool inflating packer

3. Packer inflated

OPERATION OF PRESSURE PROBE



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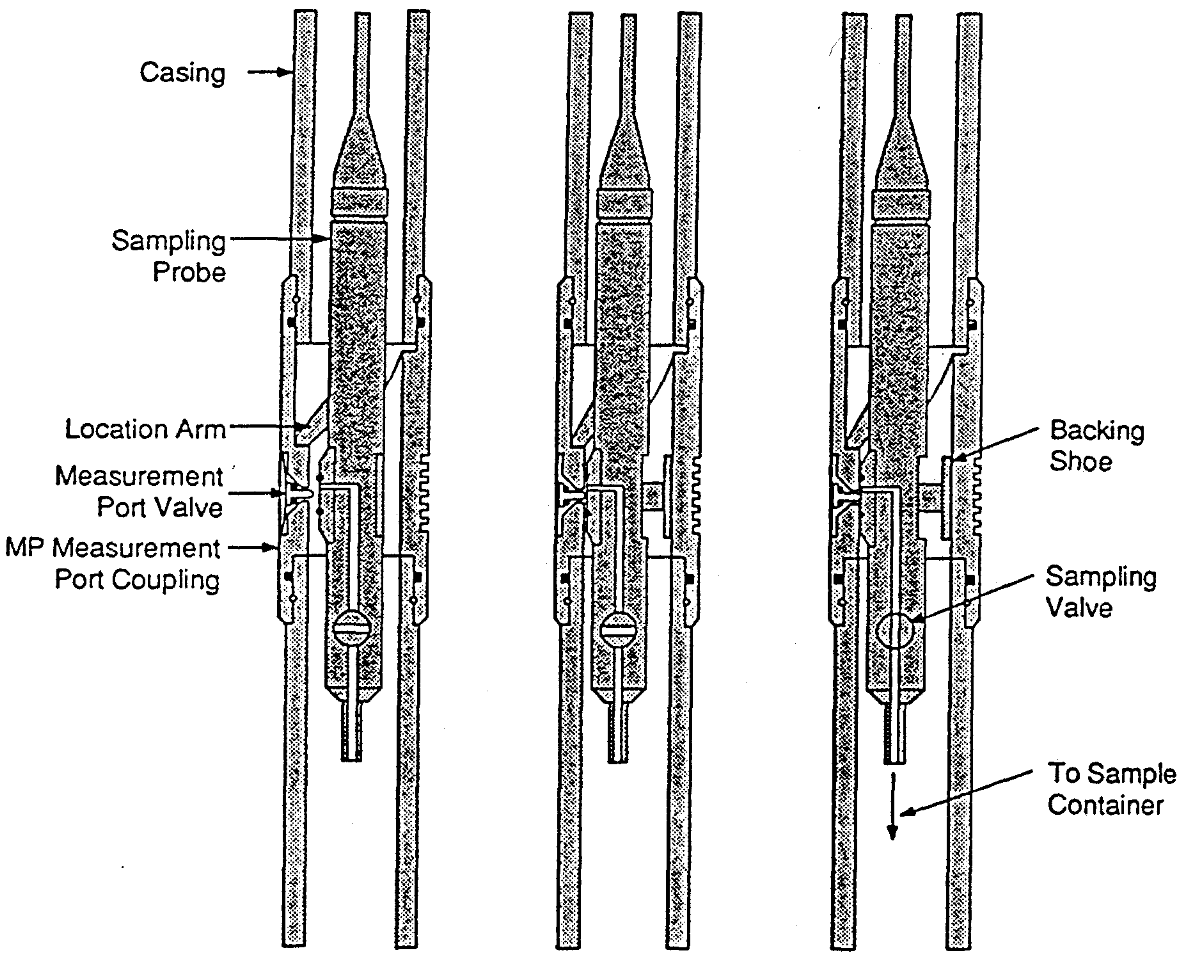
OPERATION OF A SAMPLING PROBE



a) Probe Located at Measurement Port Coupling. Sampling Valve Closed.

b) Probe Activated. Sampling Valve Closed.

c) Probe Activated. Sampling Valve Open.

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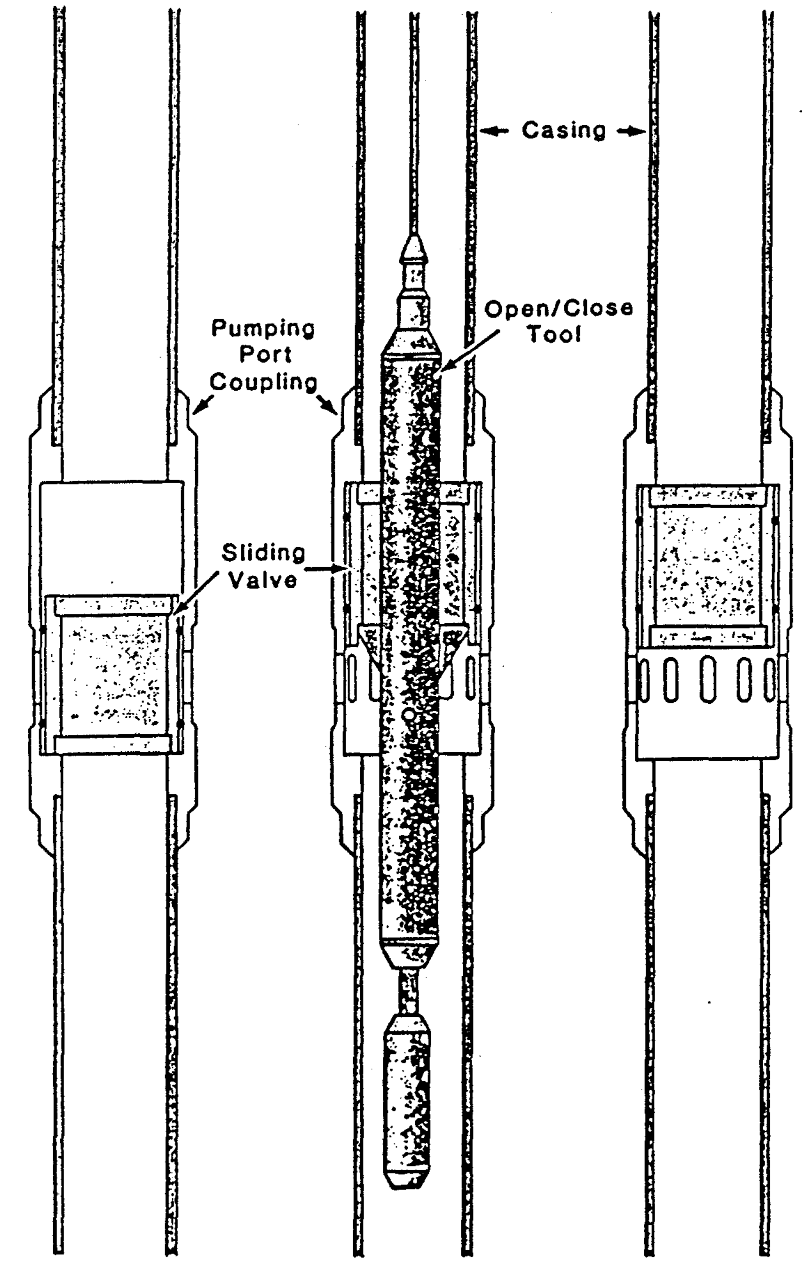
PUMPING PORT OPERATION



1. Port closed.

2. Open/Close Tool is pulled up to open Slide Valve

3. Port open.

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WESTBAY MP SYSTEM

FIELD VERIFICATION PLAN

1. Introduction

This document describes detailed testing procedures that may be undertaken in the field to verify the integrity and operation of Westbay's MP System. The procedures described herein can be performed by properly trained personnel when manuals for the MP System are consulted for detailed operating instructions for each of the specified tools and probes.

2. Verification Testing

Table 1 summarizes the tests used for verifying the integrity and operation of the MP System. Following is a description of these tests.

2.1 Hydraulic Continuity of Assembled Casing Components

Proof of the hydraulic continuity of the assembled casing components is an essential part of field quality control procedures. Leaks could occur in any of the casing components. Such leaks may not be serious, depending on their location and magnitude. However, the observations made during many of the other tests in this document generally assume that no leaks are present in the casing. Further, leaks may distort the natural distribution of groundwater pressures and chemistry. Usually any such distortion would be minor and temporary unless more than one leak is present in zones with different piezometric levels, thus permitting cross-flow from one zone to another.

2.1.1 Manufacturer's Test Certificates

Near the completion of the manufacturing process each valved coupling and packer is subjected to an internal hydraulic pressure test. A test certificate is packaged with each valved coupling and packer. This certificate should be collected in the field and the serial number recorded on the field casing installation log for the appropriate casing component. This record provides traceability between the manufacturing quality assurance and the field quality assurance programs.

2.1.2 Joint Testing

Hydraulic pressure testing of each joint or coupling is done at the surface after the field connection has been made and before the joint is lowered into the hole. This test is a standard activity for all MP System installations as it provides a field performance test of the joint and all related sealing surfaces as it will be functioning in the field. The Packer Inflation Tool is used to perform this test together with a Pressure Control Unit and a Motorized Pump.

The valve opening pressure of the inflation tool and the pressure gauges in the pressure control unit can be independently calibrated or the calibration may be transferred from a recently calibrated pressure probe. An internal testing pressure is selected and each joint is tested to this pressure after field assembly is completed. If no leaks are observed when the internal pressure is applied, the joint is said to have passed this test. Results are recorded on the casing installation log.

2.1.3 Hydraulic Continuity of Installed Casing Components

Testing for the hydraulic continuity of installed MP casing is simple. The water level in the casing is raised or lowered so that the pressure head inside the casing at any depth is significantly different than the pressure head acting outside the casing at equivalent depths. Verification of the hydraulic continuity of the casing is obtained if the fluid level inside the casing remains constant. Small water-level changes may occur due to thermal adjustments or gas bubbles in the casing and casing fluids or due to time-dependent strains of the casing components that occur before equilibrium has been reached with the drillhole environment. Such changes can be mistaken for small leaks.

The hydraulic continuity test is made during every installation before the packers are inflated or backfill is placed. This is the final test carried out before the casing components are fixed in the drillhole. Should a leak be discovered, its location should be determined and the appropriate casing component should be removed and repaired or replaced. The test would then be repeated after the casing string is reinstalled and again after the packers are inflated or the backfill is placed. This test may also be carried out during each set of fluid pressure measurements or during fluid sampling.

2.2 Measurement Port Operation

2.2.1 Valve Opening

Once a pressure probe or sampler probe is properly seated in a measurement port coupling, the measurement port valve is designed to open when the probe is activated. A pressure probe is used to verify that the valve will open after installation. The fluid pressure is recorded before and after activation. This provides the pressure inside and outside the measurement port valve. If these pressures are the same, then water should be taken from or added to the MP casing while the probe is still activated. The pressure recorded outside the valve should not change during the period when the pressure is fluctuating inside the casing. This procedure will verify: 1) that the valve has opened, and 2) that the face seal of the probe is capable of sealing around the valve while the probe is activated in the measurement port coupling.

Since the shape and dimensions of the face plate and face seal insert on the sampler probe are similar to those on the pressure probe, it can be assumed that the measurement port valve that opens for the pressure probe will also open for the sampler probe. However, if necessary the valve opening can also be checked for the sampler probe.

In some drillholes the MP casing can be filled to the surface with water prior to activation of the probe. This simplifies the checking procedure when this results in a significant pressure difference between the fluid inside and that outside the MP casing. After activation, the pressure recorded outside the valve should be significantly different than that previously recorded inside the casing and in general agreement with piezometric levels established for the formation from other sources. This relationship between the pressures inside and outside the valve will verify that it was properly opened.

2.2.2 Valve Closing

The measurement port valve should close automatically when a probe that has opened the valve is deactivated. If the valve closes properly, the casing should maintain its hydraulic continuity and show no signs of leakage. The test for hydraulic continuity is described in Section 2.1.3.

2.3 Pumping Port

2.3.1 Slide Valve Opening

The pumping port slide valve is opened by an upward pull with the open/close tool. The amount of movement (approximately 50 mm or 2 inches) required to fully open the slide valve is determined by observing and recording the incremental cable movement at the surface from just before to just after the valve is opened. Proof that the valve is open is obtained by observing the response of the fluid levels inside the casing when the valve is opened (provided the pressure head outside the casing was different from that inside the casing). When the pumping port is opened, the hydraulic continuity of the casing is deliberately broken at the port of interest. The fluid level inside the casing will tend to move towards the piezometric level in the formation outside the valve. The speed of the response is a function of many factors including the hydraulic conductivity of the formation, the pressure differences present, and the dimensions of the monitoring zone.

2.3.2 Slide Valve Closing

The pumping port slide valve is closed by dropping the open/close tool several times in the proper location so as to cause the arms on the open/close tool to push down the slide valve and close it. Once the valve is fully closed, the entire casing will regain its hydraulic continuity and show no signs of leakage. The test for hydraulic continuity is described in Section 2.1.3.

2.4 Casing Packer

2.4.1 Packer Inflation

Recording the response of a casing packer to inflation is the first step in evaluating packer performance. This is achieved by recording the volume and pressure at frequent intervals while water is being injected and plotting the results on a graph of pressure vs. volume. When the plotted curve is compared with data from laboratory tests and previous field experience, and evaluation of the packer in question can be made in terms of "as expected" or "unusual".

The record of inflation volumes and pressures is an important element in the field data required for future verification of the integrity of the packers. For example, it may be desirable to check the pressure of a packer either on a routine basis or following the recording of anomalous data. Testing can be carried out using the inflation tool to inject a small volume (say, 0.25 litre) of water into the packer. The water pressure required to inject the additional water into the packer relates to the current packer pressure.

2.4.2 Packer Sealing

The function of a hydraulic seal produced by a packer in a drillhole is to occupy the cavity formed by the drillhole so that the resistance to the movement of fluids through this portion of the drillhole is equal to or greater than that provided by the natural formations surrounding the drillhole in that location. A hydraulic packer is generally not designed to fill small cracks or sharp cornered re-entrant joint surfaces intersected by the drillhole. Nor will hydraulic packers block open intersecting joints in the rock just beyond the drillhole walls which may communicate with the drillhole above and below the packer. Such intersecting joints are a natural condition characteristic of the formation to be monitored. This situation has been discussed further in a paper by Patton (1989).

The achievement of an adequate seal is a function of many factors including the packer inflation pressure, the deformability of the packer gland material, the texture of the borehole walls, the shape and size of the borehole walls, the hydraulic conductivity of the adjacent formations, and expected differential fluid pressure that will act across the packer after it is inflated.

There are no widely accepted methods for testing the quality of a packer seal. Under some natural conditions, (high formation permeability) a diagnostic test cannot be made of any sealing method. Nevertheless, there are several methods available to test the seal achieved between the exterior of the packer gland and the drillhole walls. Three of these methods are described below. These descriptions include references to cases where interpretation of the test can be uncertain.

a) Natural fluid-pressure gradient along the drillhole.
By examining the data for evidence of differences in piezometric levels across a packer it is frequently possible to verify the presence of a seal. Differences in piezometric levels which exceed the repeatability of the instrument measurements indicate that the packer is achieving an effective borehole seal.

b) Induced fluid-pressure gradient along the drillhole.
In the event that the natural pressure gradient between two adjacent monitoring zones is not conclusive, the intervening seal may be further evaluated by inducing a pressure change in one of the zones and observing the response in the other.

The induced fluid pressure test is generally accomplished by opening a pumping port in the zone at one end of a packer and using an electric pressure probe to observe the fluid pressure at the other side of one or more packers. With the probe measuring the fluid pressure inside the MP casing, the pressure is adjusted (ie, slugged) and the probe is used to observe the response in the zone bearing the open pumping port (a slug test). Following this test, the probe is activated so as to be measuring the pressure in the monitoring zone across the packer(s) from the open pumping port. The slug test is then repeated as precisely as possible and the probe is used to monitor the response across the packer. The response (magnitude and delay) of the fluid pressure in the monitored interval as compared to the slugged interval reflects upon the effectiveness of the packer seal.

In zones of low hydraulic conductivity, slugging a zone between two packers may be accomplished by the use of a sampler probe with the sample bottle removed or slightly mislocating a pressure probe so as to open the measurement port valve but not seal around it. These methods provide a means of opening the measurement port valve and allowing communication of the casing fluids with the formation fluids outside the valve. The response of the water level inside the casing then reflects on the hydraulic conductivity of the monitored interval and the effectiveness of the adjacent packer seals.

c) Tracer tests. To evaluate the effectiveness of a packer seal, tracers can be injected into a monitoring zone and measurements can be made or samples taken to define the time of arrival of the tracer in other monitoring zones located on either side of the packer defining the injection interval. No arrival or a very slow arrival of the tracer front is usually an indication of a good quality packer seal. Tracer data, together with a knowledge of the piezometric levels in the vicinity, provide a basis for evaluating the quality of the packer seal. Rapid arrival of the tracer could have several causes: 1) an adequate seal but a good connection through the formation outside the seal, 2) a defective seal and no connection through the formation, or 3) a combination of these conditions.

2.5 Pressure Probe Operation

2.5.1 Transducer Calibration

Calibration checks allow constant verification of transducer performance at any time in the laboratory or at each measurement port in the drillhole.

In the drillhole, the depth of the transducer below the casing water surface can be converted to a standard hydraulic head (assuming a knowledge of a number of factors such as: depth to measurement port, casing water density, gravity, temperature, barometric pressure, etc.). The calculated head can then be directly compared with the hydraulic head acting on the probe inside the casing by converting the fluid pressure measured inside the casing to an equivalent head. Conformance or non-conformance to transducer specifications can be readily identified. For ongoing quality control, the data may be plotted as the differences between calculated and measured inside casing pressure versus depth. This plot may accompany formation pressure versus depth plots as a data verification plot.

2.5.2 Activation

The pressure probe must activate properly in order to seal against and open the measurement port valve. If the probe is properly activated in the measurement port, it will not be possible to move the probe easily by pulling upward on the cable. Also, in most cases, the fluid pressure outside the MP casing is different from that inside, so that when the probe activates and opens the measurement port valve, the pressure displayed on the surface data unit changes significantly.

2.6 Sampling Probe Operation

2.6.1 Sampler Valve Sealing

The sampler valve must remain closed while the probe is lowered down the casing to the sampling location. This can be verified by lowering the probe with its attached sample bottle to the lowest measurement port. The probe can then be retrieved. No water in the bottle indicates that the valve remained closed. This test may be required before and after each suite of fluid samples is collected.

Verification that the sampler valve remained closed during routine sampling is also possible. During test runs as above, the volume of water displaced by the probe and cable in the casing can be documented for each measurement port and retained for reference. During each sampling run, the record of the volume of water displaced in the casing should agree with the previously measured amount. This agreement is a verification that no significant quantity of water has moved from inside the casing to the sample bottle.

2.6.2 Sampler Valve Opening

Verification is needed to show that the sampler valve opens when required. The function of the sampler valve should be checked at the surface prior to collecting a sample. The sampling probe can be activated in a flushing collar with the valve closed and a vacuum applied to the collar. When the sampler valve is opened, the vacuum drops due to the presence of air in the sample container(s). This test is normally carried out before each sample is collected.

2.6.3 Probe Activation

The sampling probe backing shoe must activate when the control switch is positioned accordingly. The function of the backing shoe activation mechanism should be checked at the surface inside the flushing collar before the probe is lowered into the hole.

During the sampling procedure, the water level in the casing must be monitored. If the probe has activated properly in a measurement port, the water level in the casing will remain constant when the sampler valve is opened and it will not be possible to move the probe by pulling on the cable. If the probe has not activated properly, the water level in the casing may drop because of the casing water flowing into the sample bottle.

Table 1

Summary of Field Verification Tests for the MP System

	MP System Component	Test Description
2.1	All Assembled Components	2.1.1 Shop hydraulic Test Certificates 2.1.2 Hydraulic test of each joint after assembly 2.1.3 Hydraulic test of all casing components in hole
2.2	Measurement Port	2.2.1 Valve opening 2.2.2 Valve closing
2.3	Pumping Port	2.3.1 Slide valve opening 2.3.2 Slide valve closing
2.4	Casing Packer	2.4.1 Packer inflation 2.4.2 Packer sealing a) natural fluid pressure distribution b) induced fluid pressures c) tracer tests
2.5	Pressure Probe	2.5.1 In-situ transducer calibration by calculating a standard hydraulic head and comparing it with the measured pressure 2.5.2 Probe activation
2.6	Sampling Probe	2.6.1 Sampler valve sealing 2.6.2 Sampler valve opening 2.6.3 Probe activation

fieldverifplan

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Casing Length Measurement Record

Project:______________________ Date:____________ Project No.:__________

Location:______________________ Drillhole No.:__________ Nominal B.O.H.:__________

Casing Size/Type: ____________ Measured by: ____________ Checked by:____________

Section No.	Serial No.	Description	Nominal Length, ft. m.	Measured Length, ft. m.	Cummulative Length, ft. m.	Meas. Temp, C	Centralizers	Magnetic Collars

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Westbay Instruments Inc.

MP System Casing Installation Log

Project: __________ WB Ref: __________

Location: __________ Hole No: __________ Installed by: __________

Hole Depth: __________ MP Depth: __________ Hole Diameter: __________ Date Installed: __________

Measurement Datum: __________ Datum Elevation: __________ Date Drawn: __________

Depth,	Geological Description	Geologic Log	MP Casing Log	Serial No. Batch No.	Final Packer Pressure/Volume	Comments	Joint Tests joint	pass

Regular MP Casing   MP Packer   Settlement Casing   Measurement Port Coupling   Pumping Port Coupling   Regular Coupling

221187

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MP Packer Inflation Record

Project:________________________________ Completed By:________________________________

Location:________________________________ Date Completed:________________________________

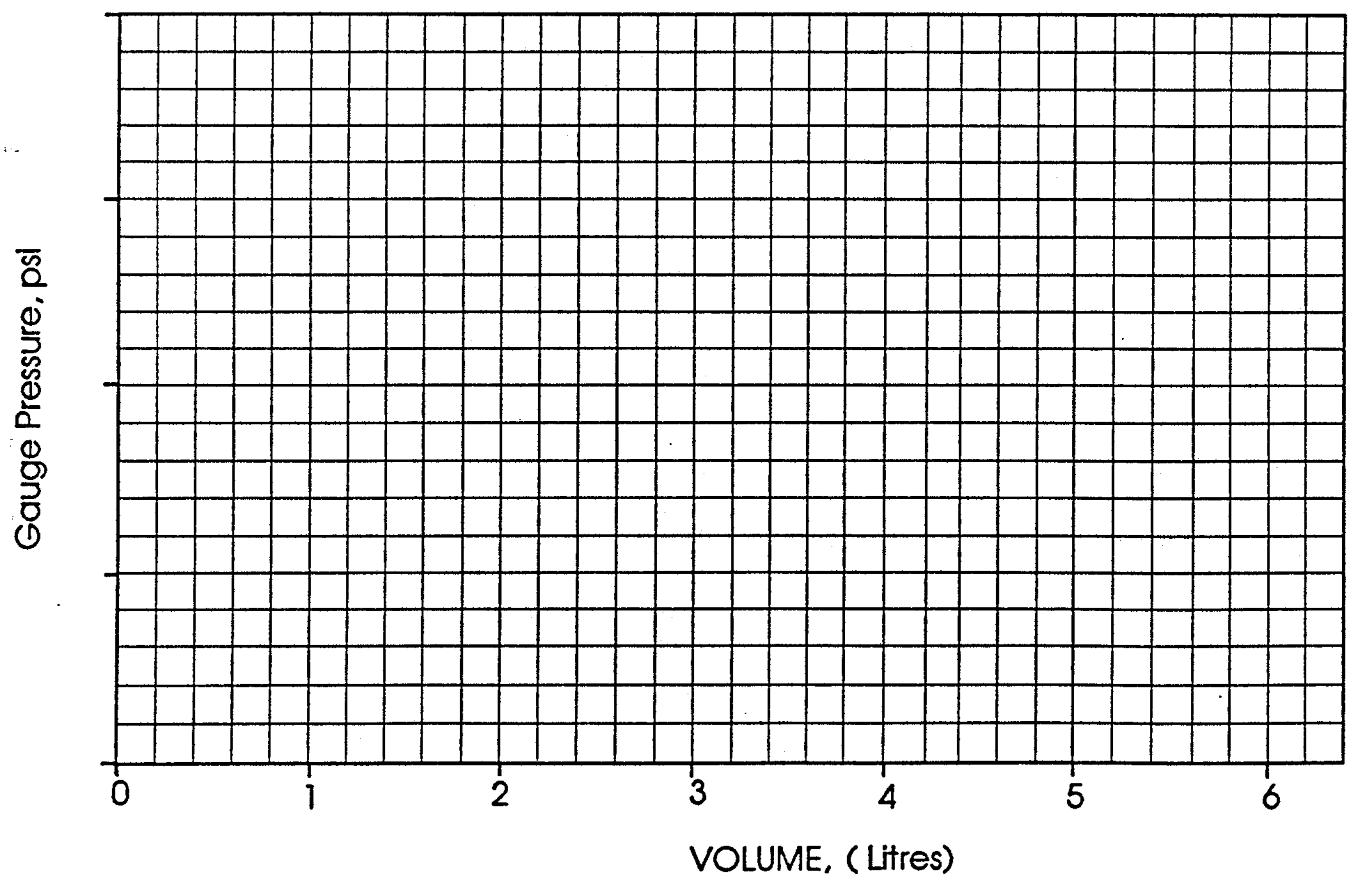
Hole No.:________________________________ Date Inflated:________________________________

Packer No.:________________________________ Depth ________________________________

Inflation Tool Setting ____________________ Depth to Water Table ____________________

Volume (L)										
Pressure (PSI)										

Plot of Gauge Pressure (PSI) vs. Volume (L)



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MP Packer Inflation Record

Westbay Instruments Inc.

Project:______________________________ Completed By:______________________________

Location:______________________________ Date Completed:______________________________

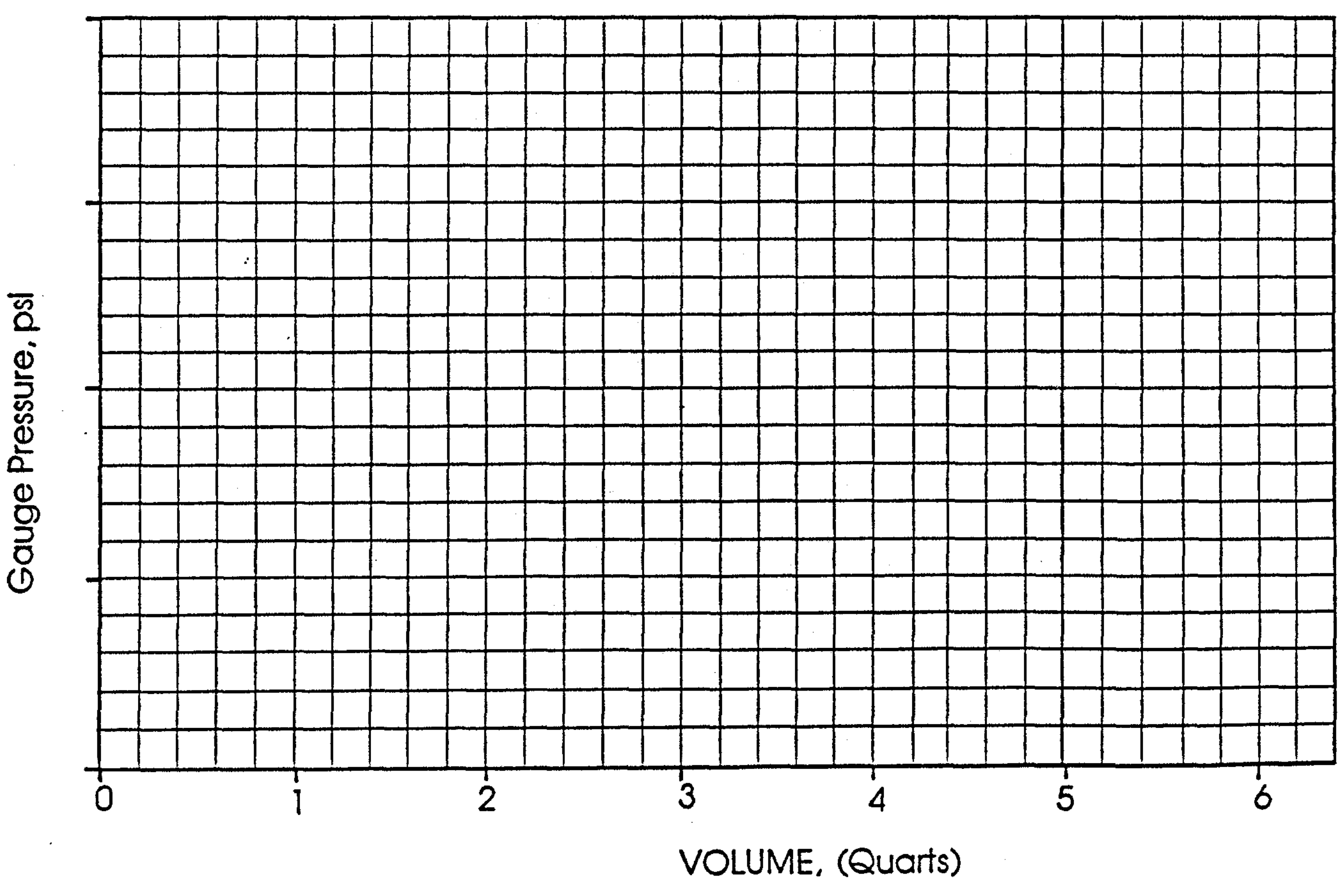
Hole No.:______________________________ Date Inflated:______________________________

Packer No.:______________________________ Depth (ft.)______________________________

Inflation Tool Setting (psi)______________________________ Depth to Water Table (ft.)______________________________

Volume Quarts										
Pressure Psi										

Plot of Gauge Pressure (psi) vs. Volume (Quarts)



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MP Packer Inflation Record

Project:______________________ Completed By:______________________

Location:______________________ Date Completed:______________________

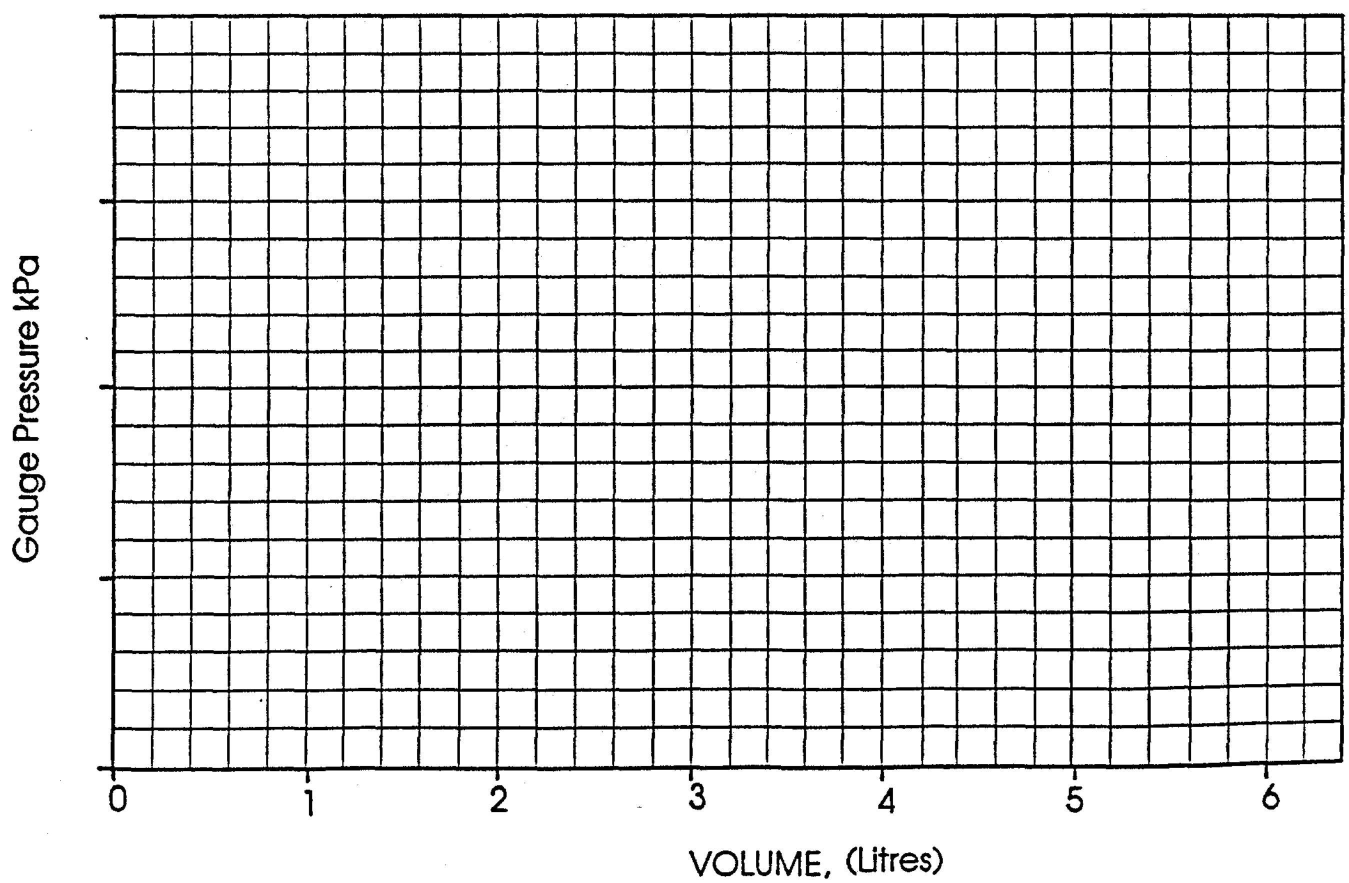
Hole No.:______________________ Date Inflated:______________________

Packer No.:______________________ Depth(m.) ______________________

Inflation Tool Setting kPa ______________________ Depth to Water Table (m.)______________________

Volume Litres										
Pressure kPa										

Plot of Gauge Pressure (kPa) vs. Volume (Litres)



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CASING COMPLETION SUMMARY

Site Location: ______________________________ Installation Date: ____________________

Drillhole No.: ______________________________ Technician(s): ____________________

Weather/Temperature: ______________________________ Job No./Client: ____________________

Completion Zone	Interval	Length	Piezometer		Pumping Port		Volume Pumped	Apparent "T"	Comments (Geology, etc.)
			#	Depth	#	Depth			

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MP System Well History

Project: ______________________________ WB Ref: __________

Location: ______________ Well No: ______________ Installed by: __________

Hole Depth: ________ MP Depth: ________ Well Diameter: ________ Date Installed: __________

Measurement Datum: ______________ Datum Elevation: ______________

DATE	DEPTH TO WATER BELOW MP START	DEPTH TO WATER BELOW MP FINISH	COMMENTS: ZONES PURGED/DATE, ZONES SAMPLED/DATE, PUMPING PORT STATUS/DATE, PRESSURE PROFILE/DATE ZONES K TESTED/DATE ETC.

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PIEZOMETRIC PRESSURES/LEVELS

FIELD DATA AND CALCULATION SHEET

Datum: ______________________ Pressure Probe Type ____________ Date: ______________________ Job No.: __________________

Elev. Ground Sfc: ______________ Serial No.: ____________________ Drillhole No.: ______________________________________

Height MP Casing above Ground Sfc: ______________ Range: 0 to__________ psi Client: ______________________________________

Elev. top of MP Casing: ______________ Weather: ____________________ Casing Size/Type: ______________________________

Reference Elev. Steel Casing: ______________ Barometric Pressure: ____________ Operator: ______________________________

Ambient Reading (Pressure/Temperature/Time): Start ________________________ Finish ______________________________

Depth to Meas. Port Valve, ft , m		Elev. Meas. Port ft , m	Fluid Pressure Readings psi			Trans. Temp., K	Time, H:M:S	Press. Head Outside Port, ft , m	Piez. Level Outside Port, ft , m	Comments
From Log	From Cable		Inside Casing	Outside Casing	Inside Casing					

Westbay Instruments Inc.

PIEZOMETRIC PRESSURES/LEVELS

FIELD DATA AND CALCULATION SHEET

Page____of____

Datum:__________ Pressure Probe Type__________ Date:__________ Job No.:__________

Elev. Ground Sfc:__________ Serial No.:__________ Drillhole No.:__________

Height MP Casing above Ground Sfc:__________ Range: 0 to__________ psia kg a/cm^2 Client:__________

Elev. top of MP Casing:__________ Weather:__________ Casing Size/Type:__________

Reference Elev. Steel Casing:__________ Barometric Pressure:__________ Operator:__________

Ambient Reading (Pressure/Temperature/Time): Start __________ Finish __________

Zone No.	Depth ft. m.	Fluid Pressure Readings psia kg a/cm^2			Trans. Temp., K	Time, H:M:S	Depth to Water in MP ft. m.	Calibration check psia kg a/cm^2	Piez. Level Outside Port, ft. m.	Comments
		Inside Casing	Outside Casing	Inside Casing						

270789

Westbay Instruments Inc.

Project ____________ Location ____________ Date ____________

Drillhole No. ____________ Sampling Zone No. ____________ Depth ____________

Sampler Probe Preparation

☐ Water Rinse I ☐ Water Rinse II Probe Serial No. ____________

☐ Stripping Rinse ☐ Evacuate Other Preparation ____________

____________ Tech'n ____________ Time ____________

Container Preparation

☐ Container Cleaned ☐ Bottom Valve Closed Container Serial No. ____________

☐ Container Purged ☐ Top Valve Open Other Preparation ____________

____________ Tech'n ____________ Time ____________

Water Level Inside MP Casing (1) ____________

Surface Function Check

☐ Probe Activation ☐ Sampling Valve Opens ☐ Container Evacuated or Initial Contents ____________

☐ Vacuum Check - Sampling Valve Closed ☐ Vacuum Check - Sampling Valve Open ☐ Sampling Valve Closed Initial Pressure ____________

____________ Tech'n ____________ Time ____________

Probe & Container Located at Sampling Port

Water Level Inside MP Casing (2) ____________ ☐ Sampling Valve Opened Time ____________

☐ Sampling Valve Closed Time ____________ Water Level Inside MP Casing (3) ____________

____________ Tech'n ____________

Probe & Container Removed From MP Casing Water Level Inside MP Casing (4) ____________

Sample Transfer

Transport Container ____________ Volume ____________ No. ____________

☐ Filtered ____________ Quantity Obtained ____________

Preservative: ☐ None or ☐ ____________ Storage/Shipping Temperature ____________

____________ Tech'n ____________ Time ____________

Field Determinations

Visual Appearance ____________ Temperature ____________ pH ____________

Specific Conductivity ____________ Dissolved Oxygen ____________ Eh ____________

____________ Tech'n ____________ Date ____________ Time ____________

Chain of Custody

270789

Westbay Instruments Inc.

Groundwater Sampling

FIELD DATA SHEET

Project ________________ Location ________________ Depth ________ Date ________

Drillhole No. ________ Sampling Zone No. ________ Starting Time ________ Finishing Time ________

Technicians ________________

Water Level Inside MP Casing __(Beginning of Session) ________ (End of Session) ________

Sampler Probe Preparation - See Sampling Plan Collection Bottle Preparation - See Sampling Plan

	SURFACE FUNCTION CHECKS					SAMPLE COLLECTION CHECKS					
Run No.	Activation	Vacuum Check Valve Closed	Valve Open	Evacuate Container	Valve Closed	Water Level in MP (ft , m)	Valve Open Time	Valve Closed Time	Water Level in MP (ft , m)	Volume Retrieved (l)	Sample Container Type
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											

Total Volume : ________

FIELD DETERMINATIONS (APPEARANCE, pH, S.C. , etc.) ________________

MR 270789

Westbay Instruments Inc.

PUMPING LOG
MP System Pumping Ports

Client: ______________________ Job No.: ______________________

Project/Location: ______________________ Technician(s): ______________________

Borehole No.: ______________________ Date: ______________________

Drill Type: ______________________

Drill Fluid: ______________________

Zone No.: ______________________ Interval Length: ______________________

Hole Size: ______________________ Interval Depth: ______________________

Elevation Head (wrt G.S.): ______________________

Recommended Minimum Extraction: ______________________

Date/Time Pumping Port Opened: ______________________ Closed: ______________________

Pump Type: ______________________

Pumping History

Date	Time	Volume Pumped	Cumulative Volume	Pumping Rate	ΔH	Comments

Apparent Transmissivity: T =

Westbay Instruments Inc.

HYDRAULIC CONDUCTIVITY TEST

FIELD DATA SHE

Page_____of_____

Datum:________________ Probe Type: ________________ Date:________________ Job No.:________________

Elev. Ground Sfc:________________ Serial No.: ________________ Monitoring Well No.:________________

Height MP Casing above Ground Sfc:________________ Range: 0 to__________ psi Project: ________________

Elev. top of MP Casing:________________ Riser Diameter (d)________in. cm Test Zone No.________________

Test Type: ________________ Test Zone Diameter: ________________ Test Zone Interval ________________

Operator ________________ Test Zone Length (L)________________

Initial Head Difference(Ho) ________________ Initial Test Reading (h) ________________

Calculated Hydraulic Conductivity (k) ________________ Analysis Method ________________

Static Water Level in Test Zone________________ft. m psi. Comments ________________

Clock Time	Elapsed Time min. sec.	Test Readings* (h) ft. m psi	Normalized Test Readings	Clock Time	Elapsed Time min. sec.	Test Readings* (h) ft. m psi	Normalized Test Readings

070788

*READINGS UNCORRECTED FOR VARIATIONS IN BAROMETRIC PRESSURE

Sheet ______ of ______

Westbay
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MP System
Pumping History

Date	Time	Volume Pumped	Cumulative Volume	Pumping Rate	Δ H	Comments

280789

APPENDIX B

OPERATIONS MANUAL FOR WESTBAY MULTI-PORT SAMPLING PROBE

Westbay
Instruments Inc.

Operations Manual
Electric Sampler Probe Model 2413
Versions 2.1 and 2.2
with
Sampler Control Model 2411

Printed in Canada

NOTICE

Operation of MP System equipment should only be undertaken by qualified instrument technicians who have been trained by Westbay authorized personnel. All warranties expressed or implied will be void if, after examination by Westbay Instruments Inc. personnel, it is established that the instrument was opened without prior authorization from Westbay Instruments Inc.

This manual describes only the operation of the Westbay electric sampler system. General requirements of sampling, sample handling and preservation and detailed cleaning procedures are not addressed.

Date	REVISIONS	Pages	Initials
Feb.1/91	Model 2413 version 2.1 Samplers	all	JJD
Jul 9/91	Model 2413 version 2.2 Samplers	14 - 17	JJD

Contents

ABBREVIATED INSTRUCTIONS

1. If possible, lower the water level inside the MP casing to below the piezometric level outside the measurement port to be sampled.
2. Complete the surface checks.
3. Close the sampler valve and check that the shoe is deactivated.
4. Attach a clean sample container. Evacuate the container, if desired.
5. Lower the sampler inside the MP casing to below the desired measurement port.
6. Activate the shoe to release the location arm, then deactivate.
7. Locate sampler at desired measurement port.
8. Activate the shoe; wait 10-20 sec. for the shoe to fully activate.
9. Open the sampler valve and allow sufficient time for the sample container to fill.
10. Close the sampler valve; wait 10-15 sec. for the valve to close fully.
11. Deactivate the shoe to release sampler from the measurement port.
12. Reel sampler to surface and remove sample container.
13. Open sampler valve and rinse.

NOTE Always store the sampler probe with the valve OPEN.

1. DESCRIPTION

1.1 Sampler Probe - Model 2413

The electric sampler has three primary functions - extending the shoe, opening the sampler valve, and sensing the presence of magnetic collars on the outside of the casing string.

The shoe, which is activated by an electric motor, pushes the probe against the wall of a measurement port coupling, seals the face seal and opens the measurement port valve. On its first activation, the extension of the shoe also releases the spring-loaded location arm which is used to precisely locate the probe at a measurement port valve.

The sampler valve is also activated by an electric motor and may be opened or closed, providing a passage from the measurement port into the sample container.

On passing through a magnetic collar, a reed switch in the sampler probe will cause a tone to be emitted from the surface control unit. This feature assists in the correct location of the probe, particularly in very deep MP casing installations.

1.2 Surface Control Unit - Model 2411

The operation of the sampler probe is controlled using the surface control unit. This box is fairly simple, consisting primarily of an input power connection, a signal output connector to the cable reel, a function selection switch, a backing shoe control switch and a magnetic location system tone device.

The reed switch for locating magnetic collars is located in the electronics section of the sampler probe. A tone is emitted from the surface control unit when the reed switch is located in a magnetic field. The tone is generated by developing a short-circuit in the control system, hence the probe cannot be operated when the tone is sounding. As a result, the locations of magnetic collars on the MP casing must be carefully chosen.

The tone will also sound as indication of the following:

- a short-circuit in the cable that connects the control box to the reel, or in the probe cable or connectors
- flooding of the probe body or cable connector resulting in short-circuiting of internal leads
- a discharged surface battery.

In general, a malfunctioning tone should be treated as a serious warning of a probe or surface malfunction and repair should be initiated immediately. Please contact Westbay for direction.

1.3 Cable Reel - Model 2135

For most MP installations, the manual cable reel (Model 2135) is sufficient to operate Westbay probes and tools. This reel has a nominal capacity of 300m (1000 ft) of unjacketed cable. It is hand operated with an internal brake to control the speed of descent of the probe. A connector on the armoured single conductor cable provides the connection to the probe. The two-pin cable from the surface control unit connects to the reel. The signal passes across a slip ring in the hub of the reel and then into the control cable. For maintenance information, see Appendix A.

Other cable reels are available for applications where the manual cable reel is insufficient (for example, motorized cable reels for installations over 1000 ft). For more information, see the appropriate cable reel manual.

1.4 Sample Containers

There are currently two primary types of sample containers in use with the electric sampler. The non-vented stainless steel sample bottle (No. 2406) has a volume of approximately 250 ml and can contain a sample under formation pressure while the sampler and bottle are brought to the surface. The bottle may also be used to keep the sample pressurized during transport to a laboratory.

The VOA bottle holder (No. 2215) holds a standard 40 ml glass sample bottle with septum. The holder incorporates two hypodermic needles which puncture the septum of the glass bottle; one needle fills the bottle while the other vents the bottle. Use of this bottle holder allows small samples, such as those used for volatile organic analysis, to be injected directly into the glass bottle in-situ.

Please refer to the appropriate appendix manual for more detailed operation and maintenance instructions for the bottle being used.

2. SURFACE CHECKS AND PREPARATION

2.1 Field Data Sheet, Sample

A Sample of a Westbay Groundwater Sampling Field Data Sheet is found on page 5. It serves as a checklist for the steps involved in sampler probe preparation and operation.

2.2 Items Required

1) Electric sampler surface control unit, Model 2411.
2) Interconnecting lines: (i) Battery pack to control unit
   (ii) Control unit to cable reel
   (iii) Probe battery charger jumper.
3) Electronic series sampling probe, Model 2413 with faceplate for plastic or steel measurement port couplings.
4) Electric series cable reel. Length and type of cable dependent on depth of hole.
5) Sample containers and connecting tubes.
6) Installation log showing depths to ports and all couplings in hole to be sampled.
7) 12 volt DC, 1/2 amp power source (battery pack, car/truck, or transformer).
8) Westbay battery charger, Model 2141.
9) Water level measuring tape.
10) Sheave with counter and tripod.

Other items will be required to handle and store the samples. As these items are project dependent, they are not listed here.

NOTE Decontaminate the sampler probe and sample bottles in a manner acceptable to the applicable sampling protocols. Activating the probe in the flushing collar supplied with the sampling kit and opening the sampling valve may simplify rinsing the probe passages with solvents, acid rinses, de-inozed water, etc. It may be desirable to flush the probe with nitrogen or other inert gas as a final decontamination step. All decontamination/preparation steps should be documented for quality assurance purposes. Decontamination may include rinsing with monitoring zone water collected during the first trip to a measurement port. The O-rings in the sampler probe and sample containers have been lubricated with silicone-based lubricant. The use of solvents during decontamination of the probe and/or containers may remove these lubricants, making assembly/disassembly of the probe and containers more difficult. Alternate lubricants compatible with project requirements may be used in consultation with Westbay.

Westbay

Groundwater Sampling

Field Data Sheet

Project ______________________ Location ______________________ Depth __________ Date __________

Drillhole No. __________ Sampling Zone No. __________ Starting Time __________ Finishing Time __________

Technicians ____

Water Level Inside MP Casing (Beginning of Session) ______________________ (End of Session) ______________________

Sampler Probe Preparation - See Sampling Plan   Collection Bottle Preparation - See Sampling Plan

	Surface Function Checks					Position Sampler	Sample Collection Checks							Comments
Run No.	Activate	Vacuum Check Valve Closed	Valve Open	Evacuate Container	Valve Closed	Deactivate Set Arm Locate Port	Water Level in MP (ft, m)	Activate	Valve Open Time	Valve Closed Time	Deactivate	Water Level in MP (ft, m) Remove Tape	Volume Retrieved (liters)	
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														

16/07/92 KES

Total Volume : __________

Field Determinations (Appearance, pH, S.C., etc.) ____

2.3 Procedure

1) Remove the probe from its storage case. Inspect both the upper and lower sections for any damage. Any deep scratches or indentations may weaken the cover tubing and cause the probe to implode at depth in a drillhole. Please contact Westbay for advice on any cover tube damage.

2) Connect the valve section to the electronics section. Before attaching the flexible connector, carefully inspect the o-rings. Replace with #114 o-ring if worn or damaged. Apply a light coating of lubricant to these o-rings. Tighten the stainless steel nuts hand tight only - never use a wrench on probe housings. Overtightening puts undue stress on the aligning pin.

3) Run the control cable over the sheave assembly and connect the probe to the control cable. Before attaching, inspect the o-ring. It should be clean and intact. If worn or damaged, replace with #113 for the regular electric cable connector and with #111 for the MOSDAX type. Apply a light coating of lubricant and tighten the nut by hand only.

4) Connect the two-conductor cable from the surface control unit to the cable reel. With the POWER control in the OFF position, connect the three-conductor cable from the surface control unit to the 12 VDC power supply.

5) Attach the desired sample container(s). When attaching the sample bottle, always check to see that there is an o-ring around the 1/8-inch teflon tube which projects from the sample bottle connecting tube. For container assembly instructions, refer to the appropriate appended manual.

6) Release the location arm by switching the POWER control to the SHOE position. Wait approximately 5 seconds for the WAIT light to go out. If the wait light does not go out, the surface power supply is too low (see section 5.0). Switch the SHOE control to ACTIVATE until the location arm is released. Immediately DEACTIVATE the SHOE control. Locate the probe in the flushing collar by lifting the probe such that the location arm is slightly above the helical shoulder of the collar and then lowering the probe until the location arm rests in the location notch at the bottom of the spiral.

7) Activate the probe into the flushing collar by switching the SHOE control to ACTIVATE. The electric motor will force the backing shoe out, sealing the probe in the collar. The face seal of the probe should seal around the orifice in the collar.

NOTE If the POWER control is switched too quickly from SHOE to VALVE or from VALVE to SHOE, the WAIT light may not illuminate. Either switch the POWER control back to OFF then back to the required location or wait 5 seconds before operating either the SHOE or SAMPLER VALVE controls.

8) Switch the POWER control to the VALVE position and wait for the WAIT light to go out. Switch the SAMPLER VALVE control to close. The electric motor should run briefly (about 5 seconds) and close the valve.

9) Use the vacuum pump to apply a vacuum through the flushing collar. Due to the small volume of air between the vacuum pump and the closed valve, a vacuum should be established quickly. Monitor the vacuum on the guage attached to the vacuum pump. The vacuum should remain constant. If the vacuum is not maintained, inspect the face seal of the probe, connection between the pump or the probe sampling valve for leaks.

10) Once a vacuum has been maintained, switch the SAMPLER VALVE control to OPEN. Reapply and monitor the vacuum to check that all connections between the probe and container are sealed. Evacuation should take somewhat longer due to the larger volume of the sample container(s).

11) Switch the SAMPLER VALVE control to CLOSE. A vacuum has now been applied to the sample container(s). Leave the SAMPLER VALVE control in the CLOSED position.

12) Switch the POWER control to the SHOE position and wait for the WAIT light to go out. Switch the SHOE control to DEACTIVATE. The shoe will retract, freeing the probe. Switch the POWER control to the OFF position. Leaving the power off is acceptable and preserves surface battery life. The POWER control must not be in the OFF position if operation of the magnetic location system is desired. The tone can be checked by passing a magnetic collar over the centre of the electronics section of the probe.

13) To reset the location arm, the shoe must be activated just until the arm can be lightly pushed into position. The location arm is then held in position and the shoe is quickly deactivated. The actuator nut will retract and hold the location arm in place. The shoe should never be allowed to fully activate when not inside MP casing or a coupling.

3. DRILLHOLE SAMPLING

3.1 Procedure

NOTE This procedure covers only the operation of the sampler and does not include such necessary procedures as removal of the effects of drilling or preservation of the water sample. The project chemist should be consulted for proper equipment cleaning and sample handling instructions. Procedures may vary depending on the analysis methods used.

1) Obtain the completed casing log for the specific hole to be sampled. This log should give the depth to all couplings including those from which water samples are required.

2) After completing the surface checks and sampler probe preparation, lower the sampling probe down inside the MP casing to a point slightly below the measurement port coupling to be sampled. If magnetic collars have been installed, these can be used to assist in locating the ports. The reed switch which triggers the tone emission when passing through a magnetic collar is located 45 cm above the location arm.

Caution When activating any probe below the area of interest, be careful not to have the probe located in another coupling. When the probe is swinging freely, the backing shoe may activate into the wider section of a coupling and jam there.

3) Switch the SHOE control to ACTIVATE for approximately 5 seconds to release the location arm then return the SHOE control to DEACTIVATE.

4) Raise the probe to slightly above the measurement port to be sampled. Lower the probe until it latches into the location notch in the measurement port coupling. If the probe fails to latch at the port, repeat step 3 and allow more time for the backing shoe to activate and release the location arm.

5) Check recent pressure logs of the hole and ensure that the head inside the MP casing is lower than the head outside the measurement port to be sampled. By following this procedure, small volume changes during port activation and sealing will have a minimal effect on sample chemistry.

6) Record the depth to water inside the MP casing using a water level tape.

7) With the probe properly located at the measurement port, turn the POWER control to SHOE and wait for the WAIT light to go out. Then turn the SHOE control to ACTIVATE. Wait approximately 10 seconds for the backing shoe to fully activate. Pull gently on the control cable to check that the probe is held in the casing.

8) Turn the POWER control to VALVE and wait for the WAIT light to go out. Then switch the SAMPLER VALVE control to OPEN and allow time for the valve to open and for the sample container to fill. If long filling times are expected, turn POWER to OFF.

NOTE The amount of time required for the sample container to fill varies with the piezometric pressure and the permeability of the zone being sampled. Experience will determine the time required to sample a particular port.

9) Switch the SAMPLER VALVE control to CLOSE and allow time for the valve in the probe to close fully.

10) Switch the POWER control to SHOE, wait for the WAIT light to go out, then switch the SHOE control to DEACTIVATE and allow time for the backing shoe to fully retract. Switch the POWER control to OFF.

11) Record the depth to water inside the MP casing. If this reading is the same as the water level measurement in step 6, the sample is shown to be representative of the formation fluid and has not been influenced by the water inside the casing.

12) Reel the sampler to the surface and remove it from the MP casing.

13) If using non-vented stainless steel sample bottles, use an allen wrench to close the valve on the top end of the bottle.

14) With the face of the probe pointed in a safe direction, switch the POWER control to VALVE, wait, and switch the SAMPLER VALVE control to OPEN. This will depressurize the passage between the sampler valve and the container.

15) Carefully disconnect the sample container from the probe.

16) Handle the sample container according to the protocols for each particular site. Take particular care in handling pressurized samples.

NOTE If a sample has not been collected for some period of time or if pressure measurements have been made while the head in the casing was higher than the head in the formation, a more representative sample may be obtained if the first sample collected is discarded and a second sample is taken and retained for analysis.

4. RINSING INSTRUCTIONS

Before sampling, attach an injection apparatus to the connector on the lower end of the valve section, open the sampler valve and flush a rinsing solution (distilled water, deionized water, suitable solvents - consult project chemist) through the probe. This might be followed by flushing an inert gas through the probe. Special attention must be given to sampler components if solvents are used. The active volume from the face plate to the bottom of the sampler is approximately 0.7 ml. This small volume ensures easy cleaning and minimal influence on samples.

5. BATTERIES

There are two batteries for the electric sampler probe.

5.1 Surface Battery

The surface power source is a 12 volt DC supply. Typically this supply is rechargeable power-pack or an automotive 12 volt supply. The current drawn from the supply will be 0.5 amp maximum.

If the surface power source is low, the WAIT light on the surface control unit will remain on. The current sampling cycle can likely be completed, but no further samples should be collected until the surface battery has been replaced or recharged. As the WAIT light remains on, care must be taken when switching the POWER control from SHOE to VALVE and vice versa. Wait approximately 10 seconds after switching functions before operating the backing shoe or the sampler valve. The surface battery life can be extended by leaving the POWER switch in the OFF position except when operating either the backing shoe or sampler valve. If the surface battery is very low, the magnetic location sounder will begin to beep. At this charge level the unit probably will not operate the probe.

5.2 Probe Battery

There is a 12 volt DC nickel-cadmium (Ni-Cad) battery located in the electronics section (upper section) of the sampler probe. This battery supplies power to the activation and sampler valve motors. The battery is left in the probe for recharging.

For recharging the probe battery use the Westbay Model 2141 Battery Charger and jumper cable. Plug the recharging jumper cable into the jack on the charger and attach the other end of the jumper to the lower end of the electronics section of the sampler.

The standard battery charger is designed to operate on 120 volt AC/50-60 Hz power. The operating voltage, if other than 120 volt, is stamped on the serial number plate. The yellow LED's will light when the battery is approximately 80% charged. When the charger is set on slow charge, a discharged battery should be fully charged after about 12 hours. The charger should not be used in the fast mode.

Although the charger will not over-charge the battery, the charger should not be left plugged in for long periods of time after the battery is charged. In the event that the yellow LED's light up when a battery which is known to be discharged is first connected, open the charger and inspect the fuse for failure. Replace with a 0.5 amp AGC fuse.

6. CARE AND MAINTENANCE

The electric sampler system is a precision instrument that must be routinely maintained for optimum performance. The procedures outlined here represent all that should be required to keep the instrument operating within specifications. For any additional information or advice, contact Westbay Instruments Inc.

6.1 Surface Control Unit

After each use, the control unit should be cleaned with a damp cloth to remove dirt and dust. At this time, inspect the panel -mounted components for damage or wear. If any part requires replacement, contact Westbay for additional information.

6.2 Cable Reel - Model 2135

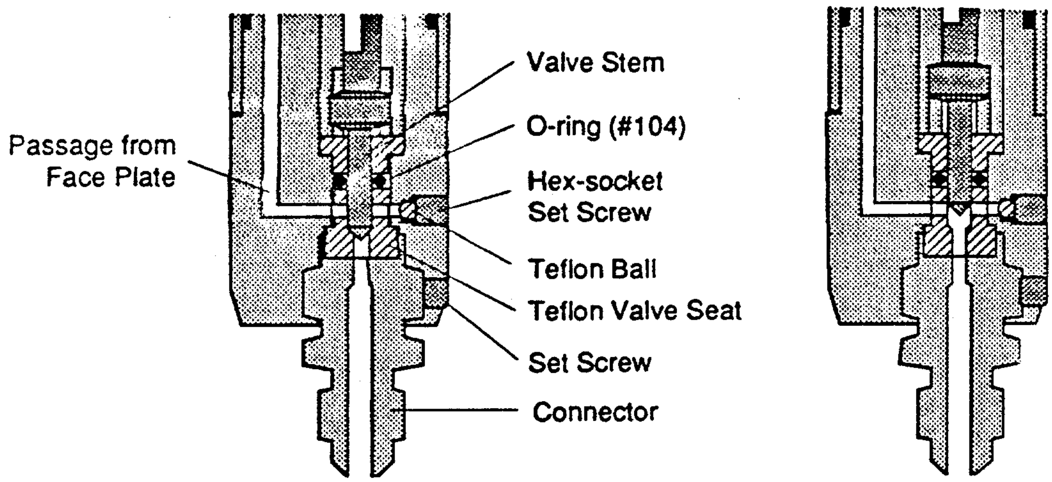
The cable reel requires little maintenance, but should be kept clean and protected from damage.

6.3 Control Cable

The control cable should be inspected for kinks and corrosion during use. The cable head o-ring must be inspected each time it is connected to the probe and should be replaced if worn or damaged. Inspect the cable armour termination inside the cable head every 2 months or after long periods of storage. Rehead the cable if necessary. For more information concerning the cable and cable reel refer to Appendix A.

6.4 Sampler Probe

1) *Never allow the electric sampler to freeze.* If water in the passage freezes, it may damage the sampler valve.
2) Always store the sampler with the valve OPEN. This will prolong the life of the teflon valve seat (See Figure 1).
3) Clean and inspect the instrument. Look for dents and deep scratches in the covertube.
4) Clean the threads on the ends of the housings with a stiff nylon brush. DO NOT use a wire brush. Inspect the contact pins to see that they are clean, dry and straight.
5) Should the face seal insert for plastic MP casing become damaged, it may be replaced as decribed in Section 6.5.1.



a) Valve Closed

b) Valve Open

Figure 1. Internal View of Sampler Valve.

6) Check the sides and end of the location arm to be sure that no sharp edges have developed due to wear. Any sharp edges may be removed by rubbing the arm with emery paper (take care not to shorten the arm). The location arm should feel smooth and all corners should be rounded. After prolonged and frequent use the location arm will become shortened and should be replaced.

   a) Use an Allen wrench to screw in the two hex-socket set screws securing the location arm access cover (immediately above the face plate).

   b) Rotate the access cover to expose the location arm pivot and use an Allen wrench to remove the pivot.

NOTE The cover tube directly above the location arm access cover may have been pressed tightly against the access cover by high external pressures when the sampler was in a well. If the access cover will not rotate to expose the pivot, it *may* be necessary to loosen the four hex-socket set screws on the upper cover in order to relieve the friction between the two covers. The set screws are loosened by turning them in.

   c) Remove the location arm and spring.

d) Inspect the spring for signs of corrosion. If it appears serviceable, place this spring on a new location arm. If not, replace both the arm and the spring.

e) Carefully place the location arm and spring in position in the probe body and screw the pivot back in place. The arm should swing freely and the spring should be positioned so as to hold the arm extended.

f) Rotate the access cover back to cover the location arm and pivot. Screw the two hex-socket set screws out until snug.

7) The shoe link is the safety mechanism for the probe. Should the motor fail to retract the shoe, pulling up on the control cable will cause the shoe link to fail, leaving the shoe plate down-hole and releasing the probe from the coupling. Regularly check the link holding the shoe. Replace if necessary (Part No. 252119).

8) The actuator screw and nut should be cleaned regularly to prolong the life of the activation motor.

a) Switch the SHOE control to ACTIVATE in order to extend the shoe lever. After the actuator stops running, remove the pivot screw and the shoe. Switch the SHOE control to DEACTIVATE.

b) Remove the side plates from the probe (4 screws with lock washers).

c) Use the 5/64" Allen key to push the shoe lever pin out of the probe body.

d) Carefully remove the shoe lever, spring and the plastic support block.

e) Switch the SHOE control to ACTIVATE. The actuator nut will run off the end of the actuator screw. Switch the power to off when the actuator nut has reached the end of its travel.

f) Carefully lift the actuator nut from the probe body.

g) Clean the actuator screw and the adjacent surfaces of the probe body. Lightly lubricate the actuator screw.

h) Use the nut cleaning tap to clean the threads of the actuator nut. Clean and lightly lubricate the exterior of the actuator nut.

i) Place the actuator nut in the probe body adjacent to the end of the actuator screw.

j) Turn the power on and switch the SHOE control to DEACTIVATE. Lightly push the nut against the actuator screw in order to engage the threads and return the actuator nut to its original position on the screw. *Be careful not the cross-thread the nut and the screw.* Turn the power off once the motor has stopped.

k) Replace the plastic support block, shoe spring and the lever in the probe body.

l) Carefully reinsert the lever pin and check the lever movement.

NOTE This page (items marked with *) applies to probes model no: 2413 **version 2.2** (produced after May 1991) only.

*7) The shoe has a safety mechanism built in. Should the motor fail to retract, pulling up on the control cable will cause the link holding the shoe in place to fail, leaving the shoe down-hole and releasing the probe from the coupling. Inspect the shoe before using the probe and replace if needed.

*8) The actuator screw and nut should be cleaned regularly to prolong the life of the activation motor.

 *a) Remove the side plates from the probe (4 screws with lock washers).

 *b) Remove two screws holding the shoe guide plate.

 *c) Use the 5/64" Allen key to push the shoe lever pin out of the probe body.

 *d) Carefully remove the shoe, shoe lever, spring, shoe guide plate and the plastic support block as a unit.

 *e) Switch the SHOE control to ACTIVATE. The actuator nut will run off the end of the actuator screw. Switch the power to off when the actuator nut has reached the end of its travel.

 *f) Carefully lift the actuator nut from the probe body.

 *g) Clean the actuator screw and the adjacent surfaces of the probe body. Lightly lubricate the actuator screw.

 h) Use the nut cleaning tap to clean the threads of the actuator nut. Clean and lightly lubricate the exterior of the actuator nut.

 *i) Place the actuator nut in the probe body adjacent to the end of the actuator screw.

 *j) Turn the power on and switch the SHOE control to DEACTIVATE. Lightly push the nut against the actuator screw in order to engage the threads and return the actuator nut to its original position on the screw. *Be careful not the cross-thread the nut and the screw.* Turn the power off once the motor has stopped.

 *k) Replace the plastic support block, shoe, shoe spring, lever, and the shoe guide plate in the probe body.

 *l) Carefully reinsert the lever pin and check the lever movement. Continue with procedure on the next page from the step **n)**.

m) Switch the SHOE control to ACTIVATE. After the actuator stops running, install the shoe on the lever with the pivot screw. Check that it rotates freely on the pivot pin.

n) Reinstall the side plates on the probe body. Tighten the screws snug only. Overtightening may damage the side plates.

o) Test-activate the sampler probe in a short piece of MP casing or a coupling to see that the backing shoe extends and holds the probe firmly in place and is retracted by the spring when de-activated.

6.5 Sampler Valve

Periodically, the sampler valve should be checked for sealing ability. An adaptor can be attached to the connector on the bottom end of the sampler to allow fluid pressure to be applied to the valve seat. The valve should be able to close and seal against a pressure of 1,000 psi (7 MPa).

Both the probe face plate and the valve seat can be removed for replacement or more thorough cleaning of parts which come into contact with the water sample.

6.5.1 Removing the Face Plate

1) Remove the two screws and lockwashers holding the face plate to the probe body and lift the face plate off.

2) The face seal insert may be removed, inspected and cleaned, or replaced.

3) The face plate plunger and the front surface of the probe body may be thoroughly cleaned.

4) Reinstall the face plate. Be sure that a face seal insert and plunger are held in place between the face plate and body.

5) Reinstall the two screws with their lockwashers.

6.5.2 Removing the Valve Seat (refer to Figure 2)

1) Remove the lower set screw which holds the connector in position.

2) Unthread and remove the connector from the valve body. The teflon valve seat should come out with the connector.

3) The valve stem, valve body, valve seat and connector may be thoroughly cleaned, rinsed and inspected. If the valve has failed a pressure test, remove the seat from the connector and install a replacement part.

4) Reinstall the connector and valve seat in the valve body.

5) Replace and tighten the lower set screw to hold the connector in position.

6) Test the valve for proper operation and sealing.

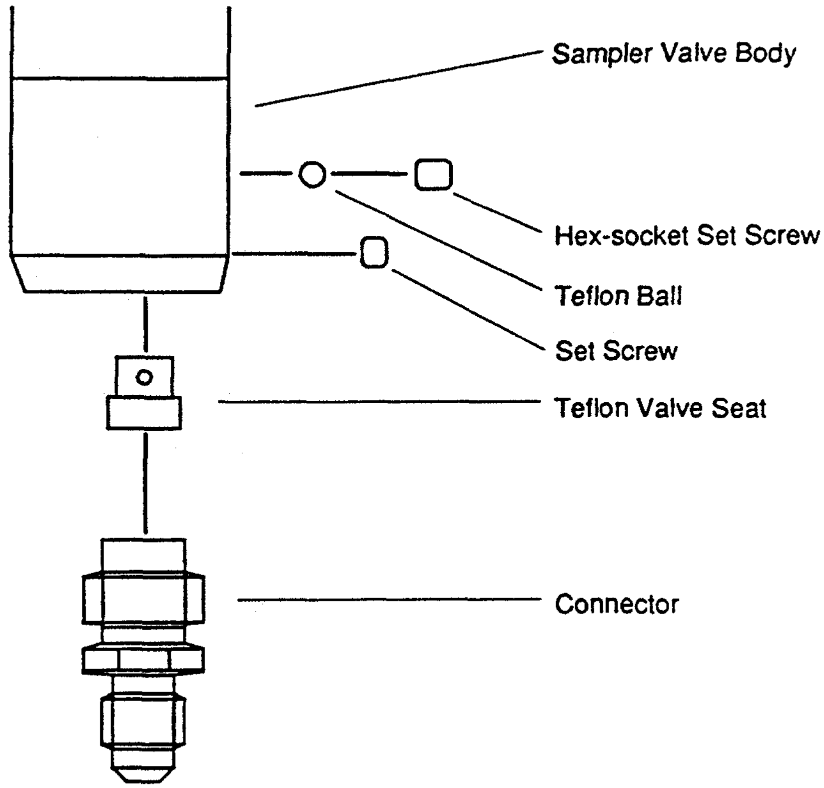


Figure 2. Exploded view of valve parts to be removed for cleaning.

Optional The teflon ball may be removed to allow flushing of the valve. Remove the hex-socket set screw and apply water pressure to the probe's face plate (with probe activated in the flushing collar, sampling valve closed). The pressure will force the ball out. After cleaning the valve, insert a new teflon ball and lock it in place with the set screw.

NOTE Always use a new set screw to avoid stripping the internal hex due to frequent use.

7. SPARE PARTS LIST

Quantity	Part No.	Description	
1	1 - 255T	Add - A - Drawer	
5	4-40 x 1/4"	Panhead screw with lockwashers	
5	241020	Location Arms	
1	252118	Location Arm Spring	
2	252113	Location Arm Pivot	
1	241314	Shoe	***
2	252119	Shoe Link	***
1	252115	Shoe Spring	
2		Fuse - 0.5 amp AGC	
2	200302	Face Seal Insert	
5	#003	O-ring, Buna-N	
5	#104	O-ring, Buna-N	
5	#113	O-ring, Buna-N	**
5	#114	O-ring, Buna-N	
5	601223	Termination Sleeve	**
5	601224	Termination Insert	**
1	2142/06	Phone Tip Jack	
1	208003	Cable Heading Tool	**
1		5/64" Hex Key	
1	208001	Cleaning Tap (Acme)	

NOTE Items marked ** are for use with the regular el. cable connector. When the MOSDAX type cable is used, parts listed below apply.

1	251805	Termination Sleeve
1	251806	Termination Insert
5	#111	O-ring, Buna-N
1	208004	Cable Heading Too

Items marked *** are used for version 2.1 samplers; parts listed below apply to version 2.2 only.

4	252109B	Shoe
1	6-32x3/16"	Pan Head Screw
1	6-32x3/8"	Pan Head Screw

APPENDIX C

OPERATIONS MANUAL FOR WESTBAY MULTI-PORT PRESSURE PROFILING PROBE

L. MACLLAN

Westbay Instruments Inc.

Operations Manual

MOSDAX Pressure Probe, Model 2521
MOSDAX Personal Computer Interface, Model 2522
Manual Cable Reel, Model 2135

Warning:

Operation of MP System equipment should only be undertaken by qualified instrument technicians who have been trained by Westbay authorized personnel.

Printed in Canada

507 E Third Street, North Vancouver, B.C., Canada V7L 1G4 Phone (604) 984-4215 Fax (604) 984-3538 Phone (in U.S.) (800) 663-8770

Notice

All warranties expressed or implied will be void if, after examination by Westbay Instruments Inc. personnel, it is established that any of the instruments have been opened without prior authorization from Westbay Instruments Inc.

Extreme care should be taken to avoid freezing the electric pressure probe. Permanent transducer damage may result from freezing.

CONTENTS

1. DESCRIPTION

1.1 MOSDAX Pressure Probe, Model 2521

The MOSDAX pressure probe is an intelligent downhole probe designed to collect fluid pressure information from MP System monitoring wells. The MOSDAX pressure probe has three primary functions: measuring fluid pressures, controlling the location arm and backing shoe motors, and communicating in a digital format to a surface device.

The MOSDAX pressure probe incorporates the following major components:

- a silicon strain-gauge pressure sensing element
- location, activation and sealing mechanisms compatible with MP System measurement ports
- a microprocessor-based electronics package which provides
  - signal conditioning,
  - analog-to-digital conversion,
  - data transmission/communication with a surface device,
  - motor control functions,
  - storage of rapid-burst measurements in on-board RAM (random access memory),
  - storage of transducer calibration constants in EPROM (erasable programmable read only memory)
  - monitoring of instrument alarm status.

Each MOSDAX pressure sensor is calibrated over its full pressure range at various temperatures. Calibration constants are determined and stored in the EPROM. When the probe is operated, the calibration constants are transmitted to the surface computer, which uses the constants to correct the pressure sensor output for non-linearity and temperature variation. Pressure probes are available in a variety of pressure ranges to permit operation to depths as great as 1,500 m (5,000 ft).

During normal pressure profiling operation, the probe transmits pressure and temperature data to the surface computer approximately once per second. In response to commands from the surface computer, the downhole electronics will release or retract the location arm and activate or deactivate the backing shoe. The power for the activation motor is supplied from ground surface.

When the MOSDAX probe passes through a magnetic collar on the MP casing string, a sensor in the electronics package will detect the magnetic field and a signal will be transmitted to the surface computer. This feature assists in confirming the location of the probe in the monitoring well. Similar alarms are transmitted in the event of detection of water within the electronics housing or low voltage at the probe.

1.2 MOSDAX Personal Computer Interface (MPCI), Model 2522

The operation of the MOSDAX probe is controlled using a PC (personal computer). The MPCI translates the signals from the computer's EIA 232 format to the format recognized by the MOSDAX probe, and vice versa. The MPCI requires 12 volt DC power to operate. An optional barometric transducer module is available to monitor the barometric pressures while the pressure profile is in progress.

1.3 Manual Cable Reel, Model 2135

For most MP installations, the manual cable reel (Model 2135) is sufficient to operate Westbay probes and tools. This reel has a nominal capacity of 300m (1000 ft) of armored single-conductor cable. It is hand operated with an internal brake to control the speed of descent of the probe in a well. A connector on the cable provides the connection to the probe. The two-pin cable from the MPCI connects to the reel. The signals pass across a slip ring in the hub of the reel and then into the control cable. For maintenance information, see Appendix A.

Other cable reels are available for applications where the manual cable reel is insufficient (for example, motorized cable reels for installations over 1,000 ft). For more information, see the appropriate cable reel manual.

2. OPERATING INSTRUCTIONS

This section describes the recommended procedure for pressure profiling a typical MP System monitoring well using the Model 2521 MOSDAX Pressure Probe System. Additional information on operating the computer program is available in the MPROFILE Software Manual.

2.1 Items Required

1. MOSDAX Pressure Probe, Model 2521.

2. MOSDAX Personal Computer Interface (MPCI), Model 2522 with:
   - one 2 pin data cable
   - one 3 pin power cable.
   - one 9 pin computer cable

3. PC-compatible Computer with MPROFILE program installed.

4. MOSDAX series cable reel. Length of cable dependent on depth of hole.

5. Installation log showing depths to ports and couplings of hole to be tested.

6. 12 VDC, 2 Amp power source. (Battery pack, car/truck, or transformer).

7. Water level measuring tape.

8. Tripod.

9. Sheave and Counter

2.2 Surface Checks

1. Remove the MOSDAX probe from its storage case. Inspect the probe housing and body for any damage. Deep scratches or indentations may weaken the cover tubing and cause the probe to implode at depth in a drillhole. Please contact Westbay for advice on any covertube damage.

2. Connect the probe to the control cable. Before attaching, inspect the O-ring at the top of the probe. It should be clean and intact. Apply a light coating of silicone lubricant. Tighten the nut <u>hand tight only</u>.

3. Connect the <u>two</u>-pin cable from the MPCI to the cable reel. With the MPCI power switch in the OFF position, connect the <u>three</u>-pin cable from the MPCI to the 12 v power supply.

4. Connect the computer cable from the EIA 232 connector on the computer to the MPCI module.

5. Turn on the computer and begin the MPROFILE program by entering "go" at the appropriate directory. Check through the "Setup" menu that the program is configured properly and through the "Well" menu that the proper monitoring well information is loaded. Refer to the MPROFILE Software Manual for detailed information on operating the program.

6. With all cables connected, move the MPCI power switch to the ON position.

7. Start the program. Check that the date and time are correct. If not, exit MPROFILE and set the correct date and time using the appropriate DOS commands for your computer. Check that the screen information is correct and is updating properly.

8. Perform the surface checks necessary to ensure that the location arm and the shoe mechanisms are operating normally. Release the location arm by depressing <ALT><F1>. The location arm should extend smoothly. Once the arm has extended, the computer should emit a beep and the screen image of the probe should change to show that the arm has been released. The right hand message box will display the number of revolutions used to release the location arm. This number should be 15 to 16 revolutions. If a smaller number of revolutions is reported, retract the arm, by depressing <ALT><F4>, and repeat the release command to reset the count. Hang the probe in a coupling placed on the top of the MP casing. Extend the shoe by depressing <ALT><F2>. The shoe should extend smoothly. Once the shoe has extended, the computer should emit a beep and the screen image of the probe should change to show that the arm and the shoe are extended. The shoe should extend and hold the probe firmly in the coupling. The message box should indicate 16 to 19 revolutions. A (maximum) reading of 23 revolutions indicates the probe is activated in open air. Retract the backing shoe by depressing <ALT><F3>.

9. Set the zone on the computer display for Atmospheric by depressing <F9> and choosing Zone 0 from the display. Record pressure and temperature readings at the surface by depressing <F5>. This automatically records both a temperature and a pressure reading and the date and time of the readings.

10. The probe is now ready to be lowered down the well.

2.3 Pressure Measurement Procedures

1. Obtain the completed MP casing log for the specific hole giving the depth to all couplings including the MP measurement port couplings from which pressure measurements are desired.

2. Run the cable over the sheave wheel assembly and suspend the pressure probe at the top of the casing (the cable manufacturer recommends a minimum sheave diameter of 15 cm). Record the ambient pressure and transducer temperature (Step 10 of section 2.2).

3. With the location arm retracted, lower the pressure probe to immediately below the lowest measurement port coupling from which measurements are needed. Check the pressure display to see that the transducer is reacting to the column of water inside the MP casing. If magnetic location collars have been installed on the well the <Alt><C> command can be used to enable collar detection software. The computer should "beep" and indicate 'COLLAR DETECTED' as the probe passes through magnetic location collars located on the MP casing. Due to timing requirements this option suspends data collection and graphing functions during operation. The Alt C command is cancelled by pressing any key. The <Alt><C> command should be enacted everytime the probe is moved to another zone equipped with a magnetic collar.

4. Release the location arm by depressing <ALT><F1> and waiting several seconds. The screen image of the probe should update and beep after the arm has been released.

5. Check the log of the casing installation to determine the length of the casing section immediately above the measurement port coupling to be measured. Raise the probe to about 0.5 m (1.5 ft) above this measurement port. If a magnetic location collar is positioned above the measurement port, the <Alt><C> command should be used: Lift the probe only until the collar is detected. If the probe is lifted above the next (higher) coupling, it will be necessary to retract the location arm <ALT><F4>, lower the probe and release the arm once more <ALT><F1>.

6. Set the zone number on the computer <F9> according to the casing installation log. Lower the probe <u>gently</u> until the location arm rests in the stop of the measurement port coupling. The weight of the probe causes the location arm to slide down along the helical shoulder in the MP coupling and come to rest in the location notch.

7. Record the pressure and temperature <F5>. This reading represents atmospheric pressure plus the pressure resulting from the head of water above the pressure probe inside the casing. To calculate the pressure due to the water column one must first subtract the atmospheric reading from the displayed value.

8. If a calibrated water level tape is available, measure and record the depth to water in the MP casing. To record the depth, press <F8> and type in the number then <CR>. This measurement may be used to increase the accuracy of piezometric level calculations.

9. Activate the shoe by depressing <ALT><F2>. The pressure on the display should change when the valve in the measurement port has been opened and the face seal on the probe has sealed around the valve. The real time graph of pressure vs. time graph should also change as the pressure changes and the probe icon should indicate shoe activation.

10. When the reading has stabilized, record the formation pressure by depressing <F5> on the keyboard. This is a reading of the atmospheric pressure plus the pressure head acting in the test zone.

11. Once the reading has been made, deactivate the shoe <ALT><F3>.

12. Before moving the probe to another coupling, record the reading of the water pressure inside the casing once again. This reading is usually the same as that recorded in Step 7. When there is a sufficient pressure differential between the formation and the casing, this second reading may be slightly different from that in Step 7 due to the transfer of a limited amount of water to or from the casing when the measurement port valve is being opened and closed. If a large difference is noted between the readings recorded in steps 7 and 12, a second measurement of the water level inside the MP casing should be made using the water level tape.

13. The three pressure readings, time, and water level constitute a complete set of readings at a measurement port coupling.

14. Continue up the borehole, taking readings at other measurement port couplings, as required.

    CAUTION: Take care to ensure that the water level tape has been removed from the MP casing when the probe is just below the water level in the MP and/or before removing the pressure probe from the well.

15. Take one last set of pressure/temperature readings at the surface (Zone 0).
    These readings should be similar to those recorded in Step 2.

3. CARE AND MAINTENANCE

The MOSDAX system consists of precision instruments which must be routinely maintained for optimum performance. The procedures outlined here represent all that should be required to keep the instrument operating within specifications. For any additional information or advice, please contact Westbay Instruments Inc.

3.1 MPCI

After each use, the MPCI case should be cleaned with a damp cloth to remove dirt and dust. At this time, inspect the panel-mounted components for damage or wear. If any part requires replacement, contact Westbay for information.

3.2 Cable Reel and Control Cable

The cable reel generally requires little maintenance, but it should be kept clean and protected from damage.

The control cable should be inspected for kinks and corrosion during use. Inspect the cable armour termination every two months or after long periods of storage. Rehead the cable if necessary. For more information concerning the electric cable reel (Model No. 2135) and the control cable, refer to the reel manual.

3.3 MOSDAX Probe

1. Never allow the probe to freeze. If water in the passage to the transducer freezes, the ice can lead to the application of extremely high pressures to the transducer resulting in a bent diaphragm.

2. Clean and inspect the instrument. Look for dents and scratches in the covertubes.

3. Clean the threads on the ends of the housings with a stiff, nylon brush (such as a toothbrush). DO NOT use a wire brush. Protect the O-rings from damage and dirt!

3.3.1 Face Seal

Should the face seal insert become damaged, it may be replaced in the following manner:

1. Remove the two screws and lockwashers holding the face plate to the probe body and lift the face plate off.

2. The face seal insert may be removed, inspected and cleaned, or replaced.

3. The face plate plunger and the front surface of the probe body may be thoroughly cleaned.

4. When reinstalling the face plate, be sure that a face seal insert and plunger are held in place between the face plate and body. Replace the two screws and lockwashers, tightening the face plate to the body.

3.3.2 Location Arm

Release the location arm by depressing <ALT><F1> on the computer keyboard. Check that the arm moves smoothly and freely. Check the sides and end of the location arm to be sure that no sharp edges have developed due to wear. Any sharp edges that are developing should be removed by rubbing the location arm with emery paper. The location arm should feel smooth and all corners should be rounded. After prolonged and frequent use or if damaged, the location arm should be replaced in the following manner:

1. With the location arm in the extended position, use an allen key to screw **IN** the two set screws which are located on the side of the probe immediately above the location arm. Rotate the cover to allow access to the location arm pivot.

2. Use an Allen wrench to remove the location arm pivot, keeping a finger over the location arm to avoid components from springing out of the housing when the pivot is removed.

3. Remove the location arm and spring.

4. Inspect the spring for signs of damage or corrosion. If the spring is in good condition, it may be used on the replacement location arm. If not, the spring should be replaced.

5. Place the new location arm and the location arm spring in the location arm slot and reinstall the location arm pivot. Note that the location arm pivot must pass through both the hole in the location arm and the loop in the spring. With the pivot in place the spring should act to keep the arm extended as much as possible. The arm should move smoothly.

6. Rotate the location arm access cover on the probe body to its original position and screw OUT the two screws to fix the cover in place.

3.3.3 Shoe

The shoe should be inspected regularly. The shoe can be pulled out for inspection by hand. If the shoe lever is supported temporarily, the shoe should swing freely about the pivot pin. When the lever is released it should spring quickly and smoothly back into the guide plate on the probe body. If required, the shoe may be replaced in the following manner:

1. Assemble the MOSDAX probe system as outlined in Section 2.2

2. Release arm <ALT> <F1> and extend shoe <ALT> <F2> to expose the shoe pivot pin.

3. Remove the two 6-32 screws from the shoe guide plate. Lift out the guide plate.

4. While holding the guide plate off the probe, remove the shoe pivot pin from the lever arm and remove the shoe.

5. While holding the guide plate off the probe, replace the shoe and install the shoe pivot pin.

6. Reinstall the guide plate inserting the SHORT 6-32 screw in the top hole (nearest location arm) and the LONG 6-32 screw in the bottom hole.

3.3.4 Lever and Actuator Nut

In order to maintain smooth operation of the actuator mechanism, the actuator nut needs to be routinely cleaned to remove particles of grit which can interfere with its movement. Remove the backing shoe nut in the following manner:

1. Remove two set screws from the side of the probe body below the faceplate which hold in the lever arm pivot pin.

2. Using the allen key push lever arm pivot pin out of the probe body.

3. Back out the single set screw from the side of the probe body which holds in the plastic termination block.

4. Remove the 6-32 screw and lockwasher closest to the location arm.

5. Lift out the lever arm, guide plate, shoe, spring and plastic termination block as a single unit.

6. Run the shoe motor until the actuator nut is no longer in contact with the threads of the motor arm (see PT program notes appendix A.) and depress <R> to stop motor. Remove nut from probe.

7. Thread the actuator nut onto the cleaning tap supplied in the spare parts kit. This will clean any grit or dirt lodged in the threads of the actuator nut. With the motor running, clean the threads of the motor arm using a stiff bristled brush such as a tooth brush. DO NOT use a wire brush.

8. Apply a thin coating of silicone lubricant to the actuator screw threads. Place the actuator nut in the probe body against the actuator screw and depress <H> to rethread the nut onto the actuator screw. Allow the nut to travel along the full length of the screw.

9. Install the single unit from step 5 in the probe body. Install the lever arm pin through the probe body, lever, and spring. Lock pin in position with 2 set screws.

10. Install the 6-32 screw and lockwasher close to the location arm.

11. Turn in the single set screw to secure the termination block in position.

3.4 Safety Features

1. The shoe has a safety break-off point built-in, should the motor fail to release the probe. By pulling up on the control cable the shoe link will fail, leaving the shoe downhole and releasing the probe from the coupling. It requires approximately 80-100 lbs tension to break the shoe link.

   CAUTION: Contact Westbay before attempting to recover a probe by this method.

2. The transducer is protected by a safety feature in case the probe is activated in regular (no port valve) couplings. The volume change is limited to O-ring compressibility and does not affect measurement at the port couplings.

4. CALIBRATION

The MP System permits frequent or periodic calibration of the transducers used for pressure measurement. Contact Westbay for details.

5. SPARE PARTS LIST

Item	*Part Number*	*Qty*
Face Seal Insert	*200302*	*2*
Plunger	*200303*	*1*
Shoe	*252109*	*2*
Location Arm	*252112*	*5*
L.Arm Pivot	*252113*	*2*
Shoe Spring	*252115*	*2*
L.Arm Spring	*252118*	*2*
Termination Sleeve	*251805*	*1*
Termination Insert	*251806*	*1*
Bulkhd.Connector	*PF0601JF*	*1*
Boot with Insert	*JF0601CF*	*1*
Fuse 1.5 GMA	*FH0150AE*	*2*
Oring	*# 110*	*2*
Oring	*# 111*	*2*
Pan Hd.Screw	*#4-40 x 1/4"*	*2*
Lockwasher	*#4*	*2*
Hex.Socket Set Screw	*#8-32 x 1/8"*	*4*
Hex.Socket Set Screw	*#10-32 x 1/8"*	*4*
Allen Key	*5/64"*	*1*
Allen Key	*3/32"*	*1*
Actuator Nut Tap	*208001*	*1*
Cable Hd. Tool	*208004*	*1*

APPENDIX A

MOSDAX Diagnostics Program PT Operation Notes.

This program consists of a selection of diagnostic subroutines for checking the functions of a Westbay MOSDAX probe. The primary use of this program is to complete maintenance procedures on the backing shoe nut as discussed in section 3.3.4 of the operations manual.

The PT (probe test) program is normally operated directly from the MProfile diskette or its backup but may be installed in a subdirectory of the MProfile directory. This note will assume the use of a separate diskette.

Insert the MProfile diskette in drive A:

Log onto drive "A:"

Change directories "CD\DIAG"

Determine the number of the communications port connected to the MPCI. Type PT space then the communications port number.
i.e. PT_1

Allow time for the program to load and run.

An error message will appear. This is normal. Continue to wait for the menu screen to appear.

Using the arrow and return keys select "Probes" from menu.

Select "Add" option from probe menu. Enter the numeric portion of the MOSDAX probe serial number then <CR> and <CR> again to exit.

Choose the "Select" option from probe menu and select correct probe number.

Go to "Diagnostics" menu.

Select "Motor" commands.

Note: You should have already removed the probe guide plate and backing shoe assembly. Use of the "Cleanut" command with the backing shoe assembly in place will not damage the probe but is considered poor practice.

Select the "Cleanut" command and hit <CR>. This command runs the shoe motor continuously. When the actuator nut has been removed hit <R> (Release arm) to stop the motor.

When the actuator nut has been cleaned place it back in the probe body and use the <H> (home) command to rethread the nut on the actuator screw.

Use <Esc> and <Q> (Quit) commands to exit the program.

MEMO

From: Production/JJD
To: Field Services, Accounting
Subject: MOSDAX Spare Parts Kit

30 October 1991

There are two versions of the Spare Parts kit for MOSDAX Pressure Probes (model 2523); one for a single probe and a second version for the string of probes. They are basically the same parts, except the quantities of some parts were increased for the string probes. A kit for the single probe includes spares for the MPCI unit; the multiple probe kit includes spares for the Data Logger.

The spare part kits are supplied with single probes as a part of the package. For multiple probes the spare parts kit is a separate item for sale. For rentals of the string, the spare parts kit is supplied (at a price) only to customers that will be allowed to re-position the probes; otherwise the kit is part of the Westbay technician tool kit and **WILL NOT** be left at the site with the probes.

SPARE PARTS KIT (MOSDAX Pressure Probe Model 2523):

Item	Part Number	Qty(single)	[$]	Qty(string)	[$]
Face Seal Insert	200302	2	5.58	6	16.74
Plunger	200303	1	30.00	1	30.00
Shoe	252109	2	9.00	10	45.00
Location Arm	252112	5	13.00	10	26.00
L.Arm Pivot	252113	2	9.60	4	19.20
Shoe Spring	252115	2	5.00	4	10.00
L.Arm Spring	252118	2	4.42	4	8.84
Termination Sleeve	251805	1	4.70	2	9.40
Termination Insert	251806	1	4.30	2	8.60
Bulkhd.Connector	PF0601JF	1	19.50	2	39.00
Boot with Insert	JF0601CF	1	7.73	2	15.46
Fuse 1.5 GMA	FH0150AE	2	1.00	2	1.00
Oring	# 110	2	0.50	10	2.50
Oring	# 111	2	0.50	10	2.50
Pan Hd.Screw	#4-40 x 1/4"	2	0.50	5	1.25
Lockwasher	#4	2	0.50	5	0.50
Hex.Socket Set Screw	#8-32 x 1/8"	4	1.00	10	2.50
Hex.Socket Set Screw	#10-32 x 1/8"	4	1.00	10	2.50
Allen Key	5/64"	1	2.50	1	2.50
Allen Key	3/32"	1	2.50	1	2.50
Actuator Nut Tap	208001	1	34.80	1	34.80
Cable Hd. Tool	208004	1	14.25	1	14.25
	TOTAL [$]		171.88		295.04

MOSDAX HAND HELD CONTROLLER

Preliminary Documentation For Beta Test Units.

INTRODUCTION

The **MOSDAX** hand held controller is used to display fluid pressure data from MP System monitoring wells using a model 2521 **MOSDAX** (Modular Sub surface Data Acquisition System) pressure probe (and a **MOSDAX** sampler probe when available). This device works in conjunction with the **MOSDAX** Personal Computer Interface (MPCI) and has a number of features which take advantage of the special functions of the **MOSDAX** pressure probe.

The **MOSDAX** hand held control unit is currently in Beta trials with select Westbay users. Many of the more advanced features of this unit have yet to be incorporated into the software. As a result, several keys and menu items (listed elsewhere) have no functions associated with them.

Westbay would appreciate any comments and/or suggestions for future improvement.

OVERVIEW

The hand held unit as seen in figure 1-1 consists of several main components. These are as follows:

Liquid crystal display (LCD)

Membrane key pad

Interface cable

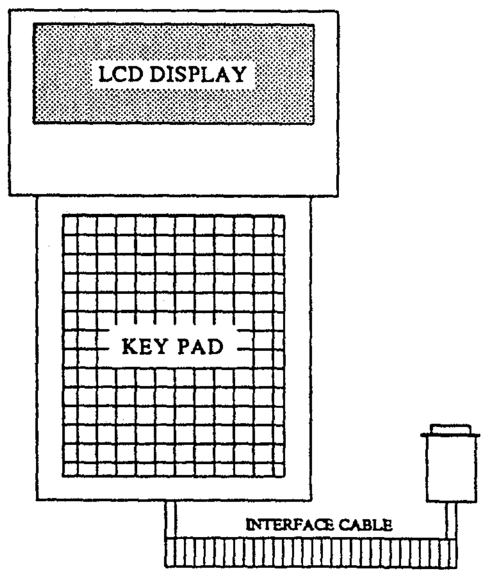


Figure 1-1

To operate the unit, first attach the interface cable from the base of the hand held unit to the 9 pin connector on the MPCI. After you have attached the power and probe connectors to the MPCI ,turn on the MPCI.

A brief title screen will appear (figure 1-2), and a message at the bottom of the screen will indicate that the calibration constants have been successfully loaded.

Figure 1-2

```
Westbay Instruments
(c) 1992   (Beta 0.6)
Please Wait.....
```

If the upload is unsuccessful, a message indicating this will appear at the bottom of the screen followed by a *COM FAILURE* message. (figure 1-3) You will be prompted to *press any key to retry*.

Figure 1-3

```
COM  FAILURE

ANY KEY TO RETRY
```

If this should happen make sure that the **MOSDAX** probe is properly connected and that all other connections are good and secure.

Once the probe is logged on, the hand held controller will display the data display screen (similar to that in figure 1-4).

Figure 1-4

```
     14.55        20.25
     (psia)        (C)
ROT: 0   HOME - CLOSED
```

Each line of the data display screen contains the following information.

Line 1 Pressure and temperature in the currently selected units (later on we will cover how to change units).

Line 2 Text description of the pressure and temperature units currently selected.

Line 3 The probe status line. First is the number of motor rotations on the last motor operation. Second is the probe motor status followed by the motor status of the sampling valve. The descriptions used in the status line are as follows:

Probe Descriptions:

Home:	Both the backing shoe and location arm are retracted into the probe body.
Arm:	The location arm is released and the backing shoe is retracted.
Shoe:	Both the backing shoe and the location arm are extended.

Valve Descriptions:

Open:	The sample valve is open.
Closed:	The sample valve is closed.

Note: If you do not have a MOSDAX sampler then you can ignore the valve status.

Line 4 This line is used to display other status or warning information. The messages you may see are as follows.

Collar:	The probe is currently located next to a magnetic location collar.
Water:	The probe has detected water inside the probe body.
Volts:	The voltage level at the probe is below the optimum threshold.

Motor Warning!: This will occur if the probe has not successfully completed the last motor function.

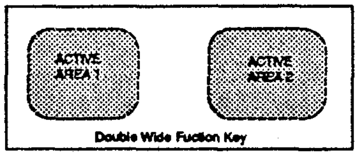
Note: During motor operation the bottom status line will indicate that the motor operation is in progress by displaying the function name.

KEY PAD

Note: There are two points that should be given special attention regarding the key pad on the hand held controller. On almost all functions the key must be held until you hear the audible *click*. The function will be executed when you <u>release</u> the key.

Secondly, all the major functions on the key pad (the larger keys) actually consist of two separate keys. This means that you must press either to the right or to the left of the key for it to operate. If you press in the center of the key it will not work.

figure 1-4a



The key pad as seen in figure 1-5 has function keys that directly control the operation of the MOSDAX probe. These are as follows:

Release Arm:	Releases the location arm.
Activate Shoe:	Extends the backing shoe.
Retract Shoe:	Retracts the backing shoe.
Retract Arm:	Retracts the location arm. This command will also retract the backing shoe if it is extended. It is used to return the probe to the *HOME* position.
Open Valve:	Opens the sample valve.
Close Valve:	Closes the sample valve.
Collar:	This key is used to enter a special collar detect mode. In this mode displaying of pressures and temperatures is suspended and only the collar detect circuitry is enabled.
Depth To Water:	For Future Use.
Record:	For Future Use.
F1:	For Future Use.
F2:	For Future Use.
Menu:	This key is used to enter the main menu. This allows you to set up the hand held controller and its operation.
->:	The right arrow key changes the display viewing angle.

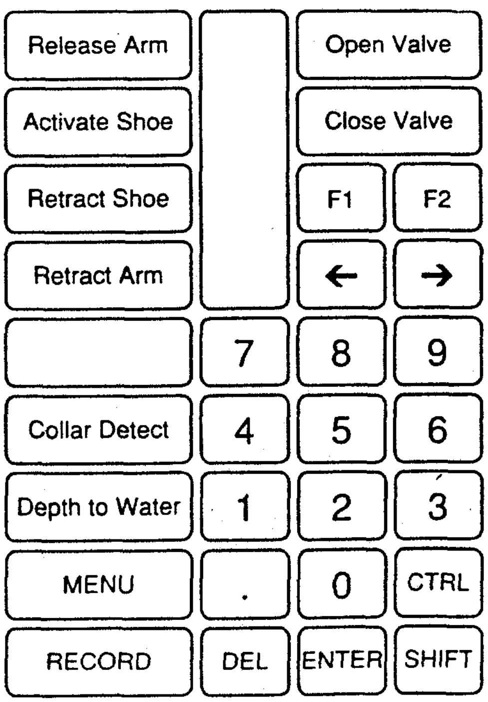


Figure 1-5

MENU

When you press the MENU button you are presented with the main menu screen. To select an item simply press the number key that matches your choice. To exit the menu press the exit key (typically 0).

In figure 1-6 is a menu tree structure. You will note that some of the menu items are not yet implemented. These will be incorporated in future releases of the hand held controller software.

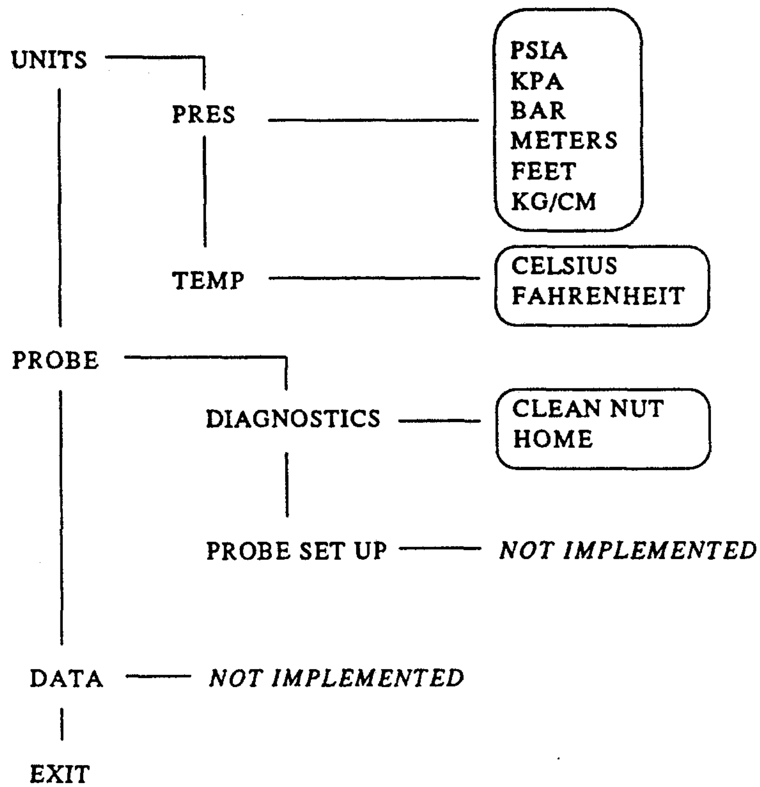


Figure 1-6

MAIN MENU

The main menu has three selections (plus exit). Only two of these items are currently enabled; these are *Units* and *Probe*.

UNITS

The units menu will give you a choice of either TEMP (temperature) or PRES (pressure). Select the one you wish to change. Under each selection is a choice of units, select the new units or press 0 to exit without changing. This will return you to the previous menu. Press 0 to exit to main menu or make another selection.

PROBE

The probe menu will give you a choice of two options, *Diagnostics* or *Probe Set Up*. Only diagnostics is implemented at this time. If you select diagnostics you will be given a choice of two menu items; these are *Clean Nut* and *Home*. These two items are motor commands and are used in the maintenance of your MOSDAX probe. Clean nut is a special motor command that is used to remove the backing shoe nut and home is used to return it to its proper position. (see probe manual for more information on probe maintenance).

Future functions

If you select an unused function key or menu item you will be presented with a display screen (similar to the one in fig. 1-x) informing you that the function is not yet available. Press any key to exit this screen.

Adjusting Viewing Angle

The viewing angle of the hand held controller can be adjusted through 8 discreet steps. This is controlled by the "RIGHT ARROW" key. Each time you press this key the viewing angle is stepped up by one increment. When you reach the last step the viewing angle returns to the first option and the process is repeated. You may have to step though all the steps once or twice until you determine the best viewing angle.

Remember as with all other main function keys. You must hold the key down until you hear the audible click and then release the key for the operation to take place.

TAKING READINGS

Over/Under Range

The MOSDAX probe might be exposed to a pressure that is above or below the operating range of the transducer. If this happens the hand held controller will blank the first line of the display and print the message "OVER/UNDER RANGE" followed by an audible alert tone. As soon as the pressure returns to the the transducer operating range , the normal pressure and temperature display will be restored. f the hand held controller should start to display "na" instead of pressure and temperature, you should take the following actions;

1.) Make a note of what you were doing prior to the problem occurring.
2.) Turn off the MPCI power switch
3.) Wait several seconds.
4.) Turn on MPCI.

If the problem persists. Check all cables and connections are tight and clean. Repeat above procedure. In the event that you still can not restore the normal display with the above procedure, you should contact Westbay Instruments customer support (see back of manual).

Pressure Profile

Here is a brief description of a typical pressure profile of a well. This is only a guide. Your actual routine may be different.

> **Note: In the following example when you see the word *record*, this means that you should write down the information on your profile sheet or in your log book. This does not refer to the *RECORD* function key on the hand held unit.**

1) At the surface read initial atmospheric pressure reading and record.

2) Lower the probe to Port 1 (normally at the bottom of the well).

3) Release the location arm by pressing function key.

4) Locate the probe in the measurement port.

5) Read inside casing pressure at port and record.

6) Activate the shoe by pressing the function key.

7) Read outside casing pressure and record when the reading is stable.

8) Retract the shoe by pressing the function key.

9) Read and record another inside casing reading.

10) Record depth to water value. This would have been obtained by means of electric tape, for example.

11) Move probe to the next port you wish to measure and repeat steps 4 to 10 of the above procedure. (If the well has magnetic location collars, you may want to use the *Collar Detect* function to help locate the port.)

12) Normally you would not have to retract the arm until after the last measurement. Do this by pressing the *Retract Arm* key.

13) Read and record the final surface atmospheric pressure after removing the probe from the well.

This completes the profiling example. If you have a copy of the MProfile software for your personal computer, then we suggest that you read the tutorial sections. Many of the concepts introduced in the MProfile tutorials will help you in the operation of the MOSDAX hand held controller and probe.

CUSTOMER SUPPORT

Support is available from Westbay. We find that telephone contact is more productive. You can call us at **(604) 984-4215** during regular office hours, Pacific Time. Ask for Software Customer Support. Or you may fax us at **(604) 984-3538**.

If calling from the U.S., call **(800) 663-8770**

It would be helpful, if, before calling:

1. You are set up to work with the equipment while on the phone
2. You have found out version and serial numbers of the equipment.

Alternatively, you may write to:

Software Customer Support

WESTBAY INSTRUMENTS INC.
507 E. Third Street
North Vancouver, B.C.
Canada
V7L 1G4

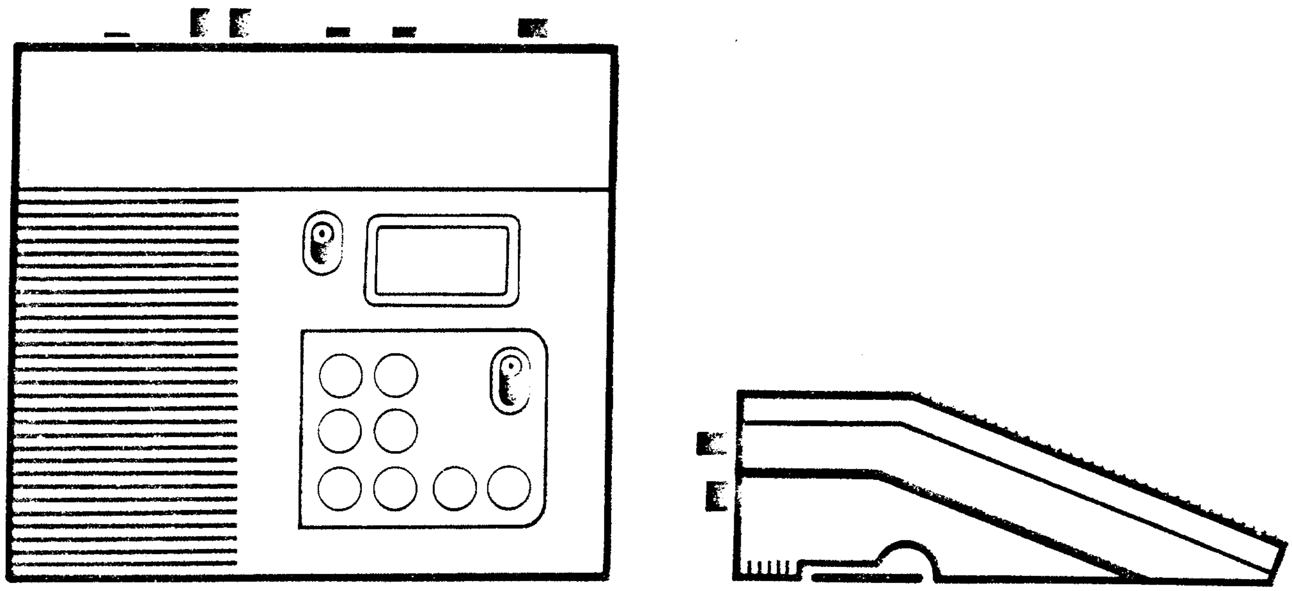
APPENDIX D

OPERATIONS MANUAL FOR ORION MODEL SA520 PH METER

ORION

Orion Research Incorporated
Laboratory Products Group

SA 520 pH METER
INSTRUCTION MANUAL



CONTENTS

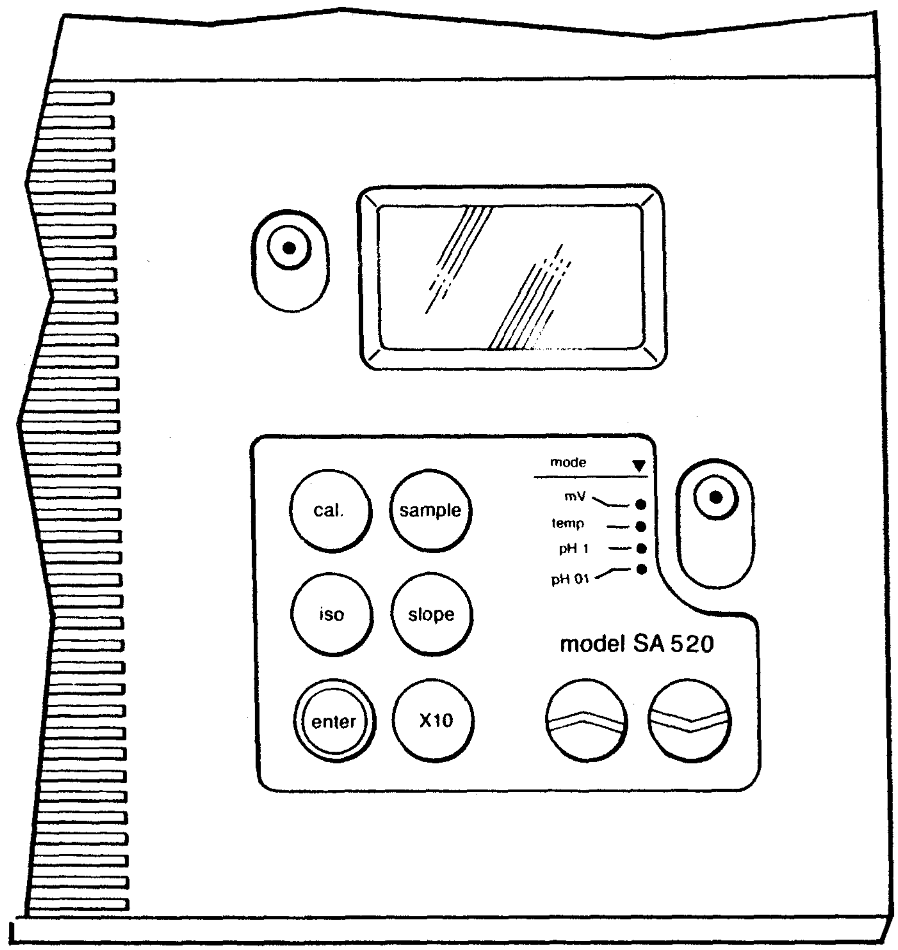
ORION SA 520 pH Meter
Autocalibration With Two Buffers and ATC

Select either Buffers 4.01 and 7.00 or 7.00 and 10.01, whichever will better bracket the expected sample range.

The ATC probe automatically senses buffer or sample temperature for use in calculating accurate pH values.

1. Connect electrode(s) and ATC probe to meter.
2. Select pH mode and resolution by sliding the mode switch to **pH.1** or **pH.01**.
3. Press **iso** and verify that the display is ***7.00***.
4. Place electrodes and ATC into either 4.01, 7.00, or 10.01 buffer.
5. Press **cal**. Display will alternate between ***.1.*** and the pH value of the buffer indicating this is the first buffer and a value has not been entered.
6. Wait for the pH value to stabilize. Press **enter**. The display will freeze for 3 seconds then advance to ***.2.*** indicating the meter is ready for the second buffer.
7. Rinse and place electrodes and ATC into the second buffer. The display will alternate between ***.2.*** and the pH value of the buffer.
8. Wait for the pH value to stabilize. Press **enter**.

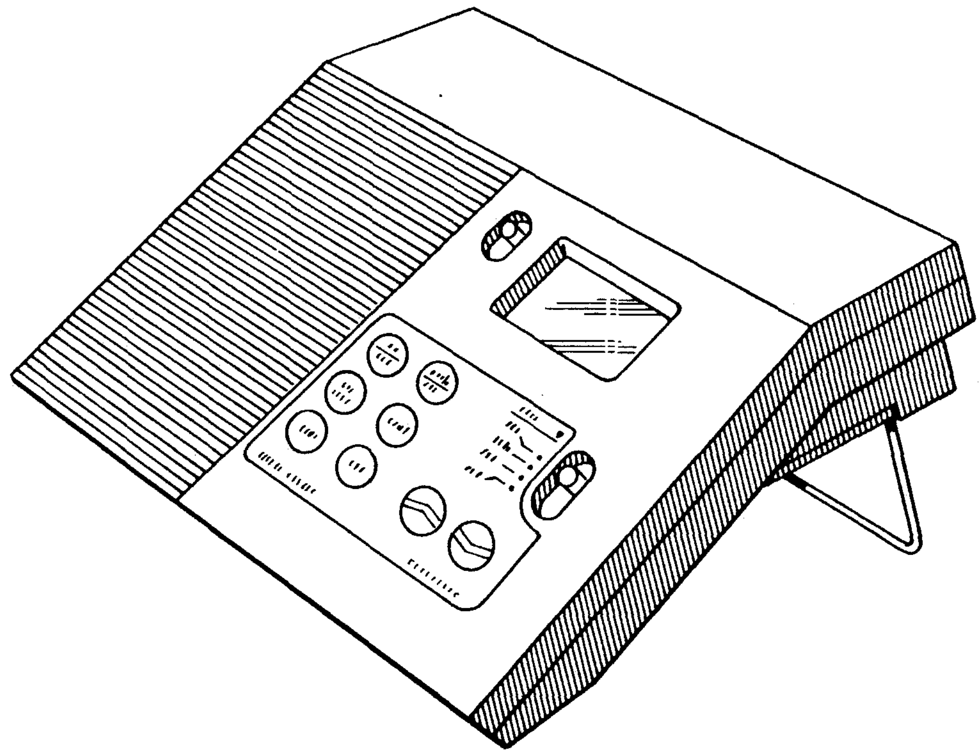
   After the second buffer value has been entered, the letters ***PH*** will be displayed.
9. The meter automatically advances to measure samples. Rinse and place electrodes and ATC into sample and read the pH directly from the display.



Printed in U.S.A.
Form 520TG/5880
Part No. 206371-001

SA 520 pH METER
TRAINING GUIDE

The ORION SA 520 pH/mV/temperature Meter gives you more value for your money than any other pH meter.



- Makes pH measurements simple to perform.
- Autocalibration recognizes and enters 4.01, 7.00, and 10.01 pH buffers. Just push the **enter** key to accept buffers and calibration is complete – you're ready to measure. But, you're not limited to using those buffers, other buffer values can be entered manually.
- The meter display automatically prompts you through 1 or 2 point calibration.
- Choice of more speed or accuracy. Get fast results with the .1 pH resolution option, or select more accuracy with the .01 option.
- Compact design saves bench-top space.
- Recorder and Karl Fischer outputs.
- Battery or line operated.
- Comes with rugged bulb, combination, glass pH electrode, ATC probe, and electrode holder.

Turn this card over for instructions on how to perform a two buffer autocalibration with ATC. Consult the meter instruction manual for initial check out, specifications, and further operational information.

ORION

Orion Research Incorporated
Laboratory Products Group
THE SCHRAFFT CENTER
529 MAIN STREET, BOSTON, MA 02129 USA
TEL 617-242-3900, 800-225-1480 / TLX 4430019
IN EUROPE: ORION RESEARCH AG
FÄHNLIBRUNNENSTRASSE 3, CH-8700 KÜSNACHT, SWITZERLAND
TEL 01-910-7858 / TLX 825767

GENERAL INFORMATION

Introduction

The ORION SA 520 Meter is a durable, microprocessor controlled pH/mV/temperature meter that gives you more value for your money than any other pH meter.

Designed to be a reliable workhorse, the SA 520 Meter is ideal for busy, multi-user labs. pH measurements are easy to do with the help of advanced features such as autocalibration, prompting, choice of .1 or .01 pH resolution, automatic temperature compensation, and diagnostic operator assistance codes.

With versatile battery or line operation and small size, the SA 520 Meter fits in anywhere, saving bench top space. The meter comes complete with a rugged bulb combination glass pH electrode, ATC probe, and electrode rod and holder – ready for immediate use.

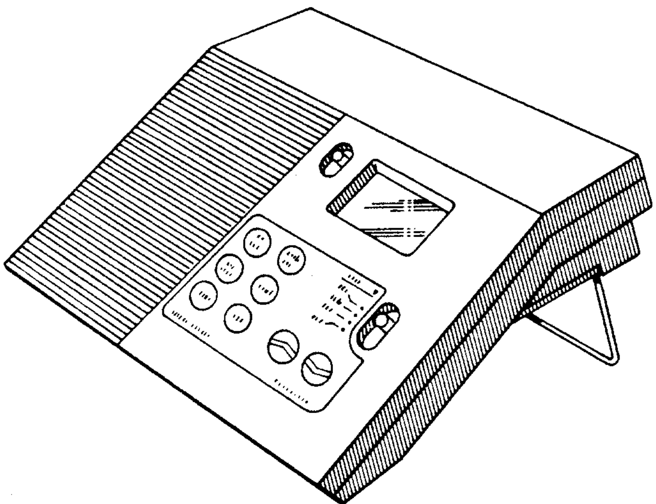


Figure 1
ORION SA 520 Meter

INSTRUMENT DESCRIPTION

Front Panel

Refer to **Figure 2**.

1 **On/off switch** Controls power to the meter. *Memory is maintained even when the instrument is turned off while connected to line power or if batteries are installed.*

2 **LCD display** Displays data on an easy to read 3 1/2 digit LCD.

3 ***Mode control*** Selects mV, temp, pH.1, or pH.01 modes.

4 **Keypad** Controls functions of the meter. Each key is labelled as to the function performed. The following table summarizes the function of each key:

Key	Function
sample	Press to display pH of sample.
cal	Press to start calibration sequence.
iso	Press to display current isopotential point.
slope	Press to display slope in percent of theoretical.

Key	Function
enter	Press to enter a value into the meter memory. The following keys, **X10**, ∧, ∨, change the numeric display. This process is called scrolling.
X10	Increases the displayed value to the next decade – for example: pH 6.14 would increase to 7.00. At the upper end of the scale, pressing **X10** will cause the display to wrap around – for example: pH 19.00 would go to –2.00. **X10** works when the mode switch is in either **pH.1** or **pH.01** and only for iso or cal adjustments.
∧ (up)	Increases the value displayed by increments equal to the least significant digit.
∨ (down)	Decreases the value displayed by increments equal to the least significant digit. *If the ∧ or ∨ key is pressed and held, the next significant digit will change.*

The **sample**, **cal**, **iso**, and **slope** keys function only while the mode control is in either **pH.1** or **pH.01**.

The ∧ and ∨ keys work in the **temp**, **pH.1** or **pH.01** modes.

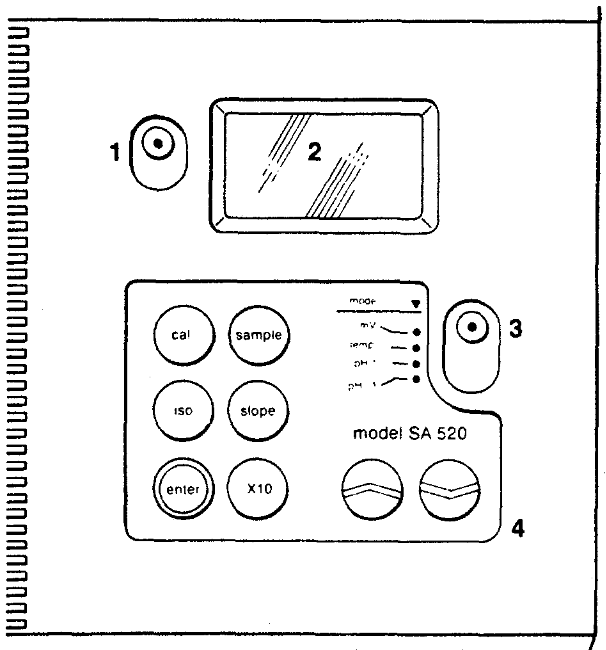


Figure 2
Front Panel

Rear Panel

Refer to **Figure 3**.

1 **POWER** Accepts an AC line converter for use without batteries.

2 **ATC** Accepts ATC probe for automatic temperature compensation.

3 **BNC input** Accepts BNC connector from combination or sensing electrodes. (Shown with shorting plug disconnected.)

4 **REF** Accepts pin-tip connector from reference electrodes.

5 **GND** Earth ground, accepts pin-tip connector.

6 **KF** Provides 10 microampere polarizing current for Karl Fischer or other polarized electrode titrations.

7 **RECORDER** Accepts banana plugs from a strip-chart recorder.

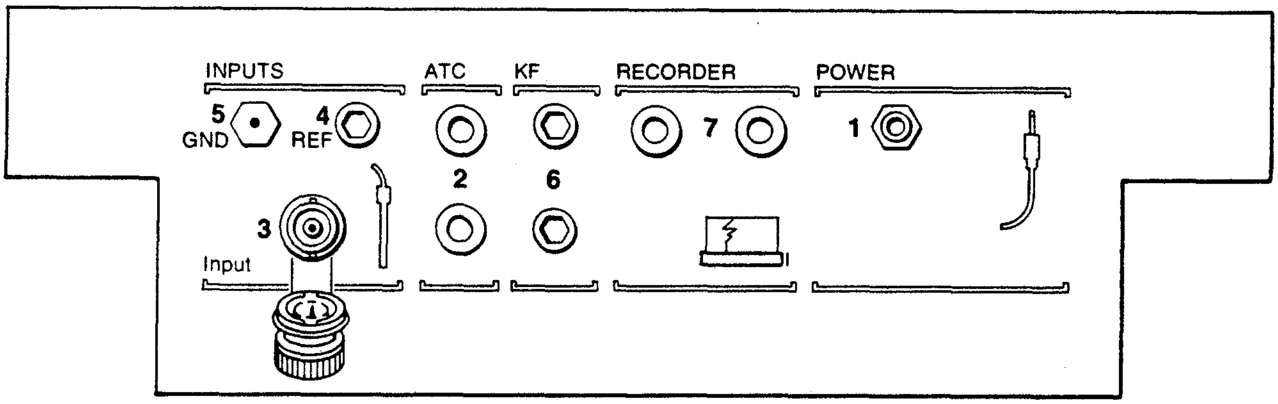


Figure 3
Rear Panel

INSTRUMENT SET-UP

Power Source

The ORION Model SA 520 pH Meter operates with an AC line converter, either 110 or 220 VAC. The SA 520 Meter may also operate with six 1.5 VAA non-rechargeable alkaline batteries. Batteries may be used as a back-up or for special uses. If the Model SA 520 pH Meter is left on while using battery power, there will be approximately 40 hours of continuous life.

Battery Installation (Optional)

1. Open access panel on back of meter by pressing down on tab allowing the door to open.
2. Install six 1.5 VAA non-rechargeable alkaline batteries and replace cover. Be sure to follow the battery orientation symbols.

Meter Check Out Procedure

1. Slide power switch to ON position. Attach BNC shorting plug (ORION Cat. No. 090045) to sensor input (**3** in **Figure 3**, page 3) on rear panel.
2. If using AC line converter, connect it to meter and appropriate power source.
3. If operating on battery power and LOBAT indicator on LCD remains on, replace batteries or use line power.
4. Slide mode switch to **mV**. Display should read ***0 ± 0.3***.
5. Slide mode switch to **temp**. Display should read ***25.0***. If ***25.0*** is not displayed, scroll using ∧ and ∨ keys, until ***25.0*** is displayed and press **enter**.
6. Slide mode switch to **pH.01**. Press **iso**. Display should read the letters ***ISO*** then a value of ***7.00***. If ***7.00*** is not displayed, scroll until ***7.00*** is displayed and press **enter**.
7. Press **slope**. Display should read the letters ***SLP*** then a value of ***100.0***. If ***100.0*** is not displayed, scroll until ***100.0*** is displayed and press **enter**.
8. Press **sample**. Observe the letters ***PH*** then a steady reading of ***7.00*** should be obtained. If not, press **cal** and scroll until ***7.00*** is displayed and press **enter**. Press **sample** and observe a reading of ***7.00***.
9. Remove the shorting plug. After successful completion of steps 1-8 the meter is ready to use with an electrode.

Electrode Connections

Refer to **Figure 3**.

Attach electrodes with BNC connectors to sensor input by sliding connector onto input, pushing down and turning clockwise to lock into position. Connect reference electrodes with pin tip connectors by pushing connector straight into reference input.

NOTE: If using a combination electrode with a BNC connector the reference pin tip jack is not used.

MEASUREMENT PROCEDURES

pH Measurements

See **Figure 2**.

A one or two buffer calibration should be performed before pH is measured. It is recommended that a two buffer calibration using buffers that bracket the expected sample range be performed at the beginning of each day to determine the slope of the electrode. This serves the dual purpose of determining if the electrode is working properly and storing the slope value in the memory. Perform a one buffer calibration every two hours to compensate for electrode drift.

Check the stored value for iso before calibration. Unless the isopotential point of the electrode is known, verify that the iso in memory is 7.00. If not, see **Isopotential Point**.

There are two ways of calibrating the SA 520 Meter, autocalibration or manual calibration. It is recommended to select either autocalibration or manual calibration and not use a combination of the two methods. Following are descriptions and instructions for each method.

Autocalibration

Autocalibration is a feature of the Model SA 520 Meter that automatically recognizes the buffers 7.00, 4.01 and 10.01 with a range of ± 0.5 pH units. The user waits until the pH display is stable and presses **enter**. The SA 520 Meter automatically calibrates to the correct buffer value using temperature compensation.

NOTE: Do not scroll when using autocalibration.

The SA 520 Meter compares actual values to theoretical values to determine if the buffer is within range. Results greater than ± 0.5 pH units from the correct value will trigger an operator assistance code. For best results, it is recommended that an ATC probe be used. If an ATC probe is not used, all samples and buffers should be at the same temperature or use manual temperature compensation. See **Temperature Mode**, page 7.

Autocalibration with Two Buffers

1. Connect electrode(s) to meter. Slide the mode switch to **pH.1** or **pH.01**. Choose either 4.01 and 7.00 or 7.00 and 10.01 buffers, whichever will bracket your expected sample range.
2. Place electrode(s) into either 4.01, 7.00 or 10.01 buffer.
3. Press **cal**. The display will alternate between ***.1.*** and the pH value of the buffer indicating this is the first buffer and a value has not been entered. Wait for a stable pH display and press **enter**. The display will freeze for 3 seconds then advance to ***.2.*** indicating the meter is ready for the second buffer.
4. Rinse electrode(s) and place into a second buffer. Wait for a stable pH display and press **enter**.

   After the second buffer value has been entered the letters ***PH*** will be displayed. The meter is now calibrated and automatically advances to measure samples.
5. Rinse electrode(s), place into sample. Record pH directly from meter display.

Autocalibration with One Buffer

1. Verify the slope value by pressing **slope**. If necessary scroll the slope value determined by a calibration with two buffers, and press enter. If slope value is unknown, either enter 100.0 or perform a two buffer calibration. A single buffer calibration does not change the slope value.
2. Connect electrode(s) to meter. Slide mode switch to **pH.1** or **pH.01**.
3. Place electrodes into either buffer 4.01, 7.00 or 10.01, whichever most closely approximates the expected sample pH.
4. Press **cal**. The display will alternate between ***.1.*** and the pH value of the buffer, indicating this is the first buffer and a value has not been entered.
5. Wait for a stable pH display and press **enter**.

   The display will freeze for 3 seconds then advance to ***.2.*** indicating the meter is ready for the second buffer. By pressing **sample** the letters ***PH*** will be displayed indicating the meter is ready for sample measurement.
6. Rinse electrode(s) and place into sample. Read the pH directly from the display.

Manual Calibration

To calibrate with buffers other than 4.01, 7.00 or 10.01, use the manual calibration technique. The calibration sequence is the same as autocalibration, except buffer values are scrolled in.

For best results, it is recommended that an ATC probe be used. If an ATC probe is not used, all samples and buffers should be at the same temperature or use manual temperature compensation. See **Temperature Mode**.

Please note that even if the correct display appears, the user needs to scroll for manual calibration or the meter will assume that autocalibration is to be used. Even if scrolling is not necessary, scroll one digit and return to the correct value.

Manual Calibration with Two Buffers

1. Connect electrode(s) to meter. Slide mode switch to either **pH.1** or **pH.01**. Choose two buffers that will bracket your expected sample range.
2. Place electrode(s) into the first buffer.
3. Press **cal**. The display will alternate between ***.1.*** and the pH value of the buffer indicating this is the first buffer and a value has not been entered.
4. Wait for a stable pH display. Scroll in the correct value, using $\wedge$, $\vee$ and **X10** keys, and press **enter**.

   The display will freeze for 3 seconds then advance to ***.2.*** indicating the meter is ready for the second buffer.
5. Rinse electrode(s) and place into the second buffer. Wait for a stable pH display. Scroll in the correct value and press **enter**.

   After the second buffer value has been entered the letters ***PH*** will be displayed. The meter is now calibrated and automatically advances to measure samples.
6. Rinse electrode(s) and place into sample. Record pH directly from meter display.

Manual Calibration with One Buffer

1. Verify the slope value by pressing **slope**. If necessary scroll the slope value determined by a calibration with two buffers, and press **enter**. If correct slope is unknown either enter 100.0 or perform a two buffer calibration.
2. Connect electrode(s) to meter. Slide mode switch to either **pH.1** or **pH.01**.
3. Choose a buffer which most approximates the expected sample range. Place electrodes into the buffer.
4. Press **cal**. The display will alternate between ***.1.*** and the pH value of the buffer, indicating this is the first buffer and a value has not been entered.

   Wait for a stable pH value display, scroll until the correct value is displayed and press **enter**.

   The display will freeze for 3 seconds then advance to ***.2.*** indicating the meter is ready for the second buffer. By pressing **sample** the letters ***PH*** will be displayed. The meter is now calibrated and automatically advances to measure samples.
5. Rinse electrode(s) and place into sample. Read the pH directly from the display.

NOTE: For* Manual Calibration, *in the event that scrolling was started but the value was not entered and the mode switch was changed, either a P1 or a P2 will be displayed upon returning to the pH mode. P1 indicates that a value has not been entered for the first buffer while P2 indicates a value has not been entered for the second buffer.

Slope

By pressing the **slope** key the slope is displayed as a percent of theoretical. When the slope is not in the range of 80 – 110%, ***E21*** appears. See **Troubleshooting**, if the slope is out of range. The slope value is retained in the meter memory until another two buffer calibration is performed or another value is entered. A one buffer calibration does not change the slope value.

At the beginning of each day and every time a different electrode is used a two buffer calibration should be performed for accurate measurements.

To enter a slope value:

1. Slide the mode switch to either **pH.1** or **pH.01**.
2. Press the **slope** key.
3. Scroll, using $\wedge$, or $\vee$ keys, until the correct value is displayed.
4. Press **enter**.

Isopotential Point

The isopotential point is the pH at which the potential (mV) of the electrode will not vary with temperature.

For the majority of pH electrodes the isopotential point is pH 7.00. There are some exceptions where the operating range used for a particular electrode is primarily at one end of the pH scale.

If your pH electrode has an isopotential point other than 7.00, the correct value may be entered as follows:

1. Select either **pH.1** or **pH.01**.
2. Press **iso**.
3. Scroll, using $\wedge$, $\vee$, or **X10** keys, until the value is displayed.
4. Press **enter**.

A two buffer calibration should be performed after an isopotential point value has been entered. It is good practice to verify the isopotential point whenever the meter has been switched on.

Temperature Mode

Sliding the mode switch to **temp** will display the temperature in °C. When the temperature is outside of the range −5.0 to 105.0°C an operator assistance code will be displayed, ***E-1*** for below −5.0°C, or ***E 1*** for above 105.0°C.

During a calibration or sample measurement, the mode switch can be changed to **temp**. When an ATC probe is connected the temperature can be monitored and automatic temperature compensation will take place.

When an ATC probe is not used, the temperature of solutions may be entered into meter memory. This is called *Manual Temperature Compensation*. The manually entered temperature value will be used to display a temperature corrected pH value.

To manually enter a temperature value:

1. Use a thermometer accurate to ±1°C and determine the temperature of the solutions to be measured.
2. Slide mode switch to **temp**.
3. Scroll, using $\wedge$ or $\vee$ keys, until the correct temperature value is displayed.
4. Press **enter**.
5. Return mode switch to either **pH.1** or **pH.01**.

When an ATC probe is not connected, the last entered value of temperature is displayed. If a temperature value has not been entered since the removal of an ATC probe, a default value of 25°C is displayed.

Potentiometric Titrations

Potentiometric titrations are performed in mV mode using either pH, ion selective or redox electrodes. Detailed instructions for any ORION electrode are given in the electrode instruction manual. Titration instructions are included in the ORION Redox Electrode (Model 96-78 or 97-78) Instruction Manual, or in standard analytical chemistry texts.

Dissolved Oxygen Measurements

Dissolved oxygen measurements are displayed in ppm when the ORION Model 97-08 Dissolved Oxygen Electrode is used with the ORION SA 520 Meter. Follow these instructions for preparing the meter and calibrating the electrode.

1. Connect the Model 97-08 to meter and leave electrode mode switch "off".
2. Do not use an ATC probe. (ATC probe must not be connected to meter.)
3. Set the mode switch of the Model SA 520 Meter to **temp** and scroll in 25.0°C, press **enter**.
4. Set the mode switch to **pH.1** or **pH.01**.

Dissolved Oxygen Measurements (cont.)

5. Press the **slope** key. Scroll, using ∧ and ∨ keys, until the value 100.0 appears and press **enter**.
6. Press the **iso** key and verify that it is 7.00. If not, scroll in the value 7.00 and press **enter**.
7. Press the **cal** key, scroll in the value 7.00 and press **enter**.
8. Press **sample**.
9. Turn the mode switch on the electrode to BT CK. Good battery operation is indicated by a reading of ***13.00*** or greater on the meter.
10. Turn the mode switch on the electrode to ZERO. Use the zero calibration control on the electrode to set the meter to read ***0.00***.
11. Insert the reservoir (funnel) into a BOD sample bottle containing enough water to just cover the bottom. Insert the electrode, making sure that the electrode tip is not immersed in the water and does not have water droplets clinging to the outside of the membrane. Let stand approximately 30 minutes to ensure water saturation of air in BOD bottle. This bottle should be used for storage between measurements.
12. Turn the electrode mode switch to the AIR position. If measurements are being made at sea level, use the AIR calibration control on the electrode to set the pH meter reading to the prevailing barometric pressure in mm Hg (divided by 100). If the barometric pressure is unknown, if the elevation is above sea level or if the sample has a salinity greater than 2 parts per thousand, consult **Table 1** found in the *Model 97-08 Instruction Manual* to obtain the correct AIR setting.
13. Turn electrode mode switch to H_2O for sample analysis.

Polarized Electrode Titrations

A 10 microampere polarizing current is available for Karl Fischer or other polarized electrode titrations.

1. Slide the mode switch to **mV** mode.
2. Connect the BNC plug of the Karl Fischer adaptor (ORION Cat. No. 090048) to the BNC electrode input on the SA 520 Meter.
3. Push the pin tip connector of the Karl Fischer adaptor into either KF input on the SA 520 Meter.
4. Connect one pin tip connector of the Karl Fischer electrode into the Karl Fischer adaptor. Place the other pin tip connector into the reference electrode input of the SA 520 Meter.
5. Press **sample**.
6. Place electrode into sample and perform titration. (See analytical chemistry texts or other procedural methods books for specific techniques.)

STRIP CHART RECORDER

The red and black rear panel binding posts provide an output for strip chart recording of absolute mV independent of operating mode.

The voltage provided is a direct uncompensated readout of electrode output, set at a one to one ratio.

The ratio of recorder readout to electrode output may be adjusted using the control on your recorder.

1. Connect the lead from the high (input) side of the recorder to the red binding post and the lead from the low (ground) side to the black binding post.
2. Proceed according to the directions in the strip chart recorder instruction manual.

OPERATOR ASSISTANCE CODES

Operator assistance codes are used to inform the user of an out of range value. The following table outlines the operator assistance codes that are available in the Model SA 520 pH Meter and suggests a remedy. The table is divided according to the modes of the meter.

Code	Problem	Remedy
MV MODE		
E 1 ***E-1***	mV out of range.	1. If occurs when electrodes are out of solution, code will disappear when electrodes are returned to solution. 2. Verify electrodes are properly connected and filled. 3. Dilute standards or samples. 4. Review calibration and operating procedures.
TEMP MODE		
E 1	Temp out of range.	1. Verify ATC probe is properly connected.
pH.1 or pH.01 MODES **While in** sample **function**		
E 1 ***E-1***	mV, temp or pH out of range	1. Go to **mV** mode and check. If mV is out of range, perform remedy steps described above for mV mode. 2. Go to **temp** mode and check. If temp is out of range, perform remedy steps described above for temp mode. 3. Sample's pH may be out of the acceptable range. Test a buffer. 4. Check slope and iso values. 5. Re-calibrate.
pH.1 or pH.01 MODES **While in** cal **function**		
E 1 ***E-1***	mV, temp or pH out of range	1. Go to **mV** mode and check. If mV is out of range, perform remedy steps described above for mV mode. 2. Go to **temp** mode and check. It temp is out of range, perform remedy steps described above for temp mode. 3. Use fresh buffers. 4. Check iso value.
E21	Slope not in the range of 80 to 110%	1. Press **enter** to acknowledge code and repeat calibration using fresh buffers. 2. Clean electrode and refill reference electrode. 3. Refer to electrode instruction manual for check out of electrode operation.
E31	First cal point of range	1. Press **enter** and repeat calibration using fresh buffers. 2. Check iso, slope, and temp values. 3. Verify electrodes are properly connected.
E35 ***E36***	pH Autocalibration error Electrode voltage being measured is greater than ±0.5 pH units from nominal value for the pH buffer	1. Verify buffer is either pH 4.01, 7.00 or 10.01. 2. Press **enter** and repeat calibration using fresh buffers. 3. Clean electrodes and refill reference electrode. Recalibrate. 4. Perform a manual calibration. Certain electrodes may operate out of the acceptable range for pH autocalibration.

TROUBLESHOOTING GUIDE

Malfunction	Possible Cause	Remedy
No Display	No power to meter	Check that switch is in ON position. Replace batteries, if operating on battery power. Check that converter is plugged in securely.
Erratic readings or Reading out of range	Meter or electrode failure	Follow meter check out procedure. Follow instructions in electrode instruction manual.
Unable to Calibrate	Isopotential error	Verify iso.
Trouble Calibrating in Autocalibration	Certain electrodes may operate outside the limits of ± 0.5 pH units.	If **E 1** or **E-1** keep appearing, scroll to within range and press **enter** to calibrate. Check temp, slope and iso, then repeat calibration.

Orion Technical Service Chemists can be consulted for troubleshooting advice by calling 800-225-1480 or 617-242-3900. Outside North America contact your local authorized Orion Respresentative.

INSTRUMENT WARRANTY

Laboratory instruments are warranted to be free from defects in material and workmanship for a period of twelve (12) months from the date of purchase by the user or eighteen (18) months from date of shipment from Orion, whichever is earlier provided when used under normal laboratory conditions and in accordance with the operating limitations and maintenance procedures in the instruction manual and when not having been subjected to accident, alteration, misuse or abuse.

In the event of failure within the warranty period, Orion, or its authorized distributor, will, at Orion's option, repair or replace product not conforming to this warranty, or will refund the purchase price of the non-conforming product. There may be additional charges, including freight, for warranty service performed in some countries. For service, call Orion or its authorized dealer. Orion reserves the right to ask for proof of purchase, such as the original invoice or packing slip.

Economy Line electrodes are warranted to be free from defects in material and workmanship for a period of three (3) months from date of purchase by customer or six (6) months from date of shipment if the electrode fails for any reason (including breakage) except abuse, provided the electrode is not used in solutions containing silver, sulfide, perchlorate, or hydrofluoric acid; or in solutions more than 1 molar in strong acid or base at temperatures above 50°C, and providing the electrode is used at room temperature (use at extreme temperatures can shorten electrode life). For service, Orion or its authorized dealer will replace product not conforming to this warranty or refund the purchase price of the nonconforming product.

Ion-selective electrodes and pH electrodes (excluding the Economy Line electrodes) are warranted to be free from defects in material and workmanship for a period of twelve (12) months from the date of purchase by the customer or eighteen (18) months from date of shipment from Orion, except this warranty does not cover etching of the sensing elements of Models 94-17, 96-17, 97-17, and 94-06 or the breakage of non-Economy Series pH electrodes. 93 Series sensing modules are warranted to give six (6) months of operation if placed in service before the date indicated on the package, except the nitrate sensing modules are warranted to give thirty (30) days of operation if placed in service before the date indicated on the package. Replacement parts for the 92 and 95 Series electrodes and 97-08 electrode (O-rings, membranes, filling solution, etc.) are warranted to be free of defects in material and workmanship for thirty (30) days from the date of shipment.

THE WARRANTIES DESCRIBED ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES WHETHER STATUTORY, EXPRESS OR IMPLIED INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND ALL WARRANTIES ARISING FROM THE COURSE OF DEALING OR USAGE OF TRADE. THE BUYER'S SOLE AND EXCLUSIVE REMEDY IS FOR REPAIR OR REPLACEMENT OF THE NON-CONFORMING PRODUCT OR PART THEREOF, OR REFUND OF THE PURCHASE PRICE, BUT IN NO EVENT SHALL ORION (ITS CONTRACTORS AND SUPPLIERS OF ANY TIER) BE LIABLE TO THE BUYER OR ANY PERSON FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES WHETHER THE CLAIMS ARE BASED IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE), OR OTHERWISE WITH RESPECT TO OR ARISING OUT OF THE PRODUCT FURNISHED HEREUNDER.

Representations and warranties made by any person, including its authorized dealers, representatives, and employees of Orion which alter or are in addition to the terms of this warranty shall not be binding upon Orion unless in writing and signed by one of its officers.

REPAIR AND SERVICE

A Return Authorization Number must be obtained from Orion Laboratory Products Customer Service before returning any product for in-warranty or out-of-warranty repair, replacement or credit.

Consult your authorized Orion dealer, or:

ORION RESEARCH INCORPORATED
The Schrafft Center
529 Main Street, Boston, MA 02129
Telephone 617-242-3900 / Telex 4430019

In Europe, the Middle East, and Africa, contact your Authorized Orion Dealer, or:

ORION RESEARCH AG
Fähnlibrunnenstrasse 3,
CH-8700 Küsnacht, Switzerland
Telephone 01-910-7858 / Telex 57829

ORDERING INFORMATION

Cat. No.	Description
910001	pH Electrode Storage Solution, 475 ml bottle
910002	Electrode holder
910004	pH 4 Buffer Packets, box of 25 packets, each packet making 200 ml of buffer
910007	pH 7 Buffer Packets, box of 25 packets, each packet making 200 ml of buffer
910009	pH 9 Buffer Packets, box of 25 packets, each packet making 200 ml of buffer
910071	pH Solutions Bulk Pack, for use with Ag/AgCl internal pH electrodes, includes four 910110, four 910107, one 910001, two 900011, and three flip-top spout dispensers
910074	pH Solutions Bulk Pack, for use with Ag/AgCl internal pH electrodes, includes four 910104, four 910107, one 910001, two 900011, and three flip-top spout dispensers
810002	pH Solutions Bulk Pack, for use with ROSS pH Electrodes, includes four 910110, four 910107, one 910001, two 900011, and three flip-top spout dispensers
810003	pH Solutions Bulk Pack, for use with ROSS pH Electrodes, includes four 910110, four 910107, one 910001, two 810007, and three flip-top spout dispensers
700001	Pure Water pH Test Kit includes four 475 ml bottles L.I.S.* pH buffer a, 6.97; two 475 ml bottles L.I.S.* pH buffer b, 4.10; two 50 ml bottles pHiX adjustor, one 1 ml syringe, one holding tray, instruction card and Orion Application Procedure No. 501. (*Low Ionic Strength)
910104	pH 4.01 Buffer, color coded, 475 ml bottle
910107	pH 7.00 Buffer, color coded, 475 ml bottle
910110	pH 10.01 Buffer, color coded, 475 ml bottle
917001	Automatic temperature compensator — epoxy outer body
917002	Automatic temperature compensator — glass outer body
090033	U.S. Standard electrode to BNC meter adaptor
090045	Shorting plug
9678BN	Redox electrode
970899	Dissolved oxygen electrode
020120	110 VAC line converter
020121	220 VAC line converter (DIN main connector)
020045	Support base, rod and electrode holder
977900	Double platinum electrode (Karl Fischer)
090048	Karl Fischer adaptor

NOTICE OF COMPLIANCE

WARNING: This meter may radiate radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J or Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a commercial environment. Operation of the meter in a residential area may cause interference in which case the user at his own expense will be required to take whatever meaures may be required to correct the interference.

SPECIFICATIONS

mV
−999 to 999

Temperature
−5.0 to 105.0°C

pH
−2.00 to 19.99

Isopotential
0.01 to 19.99

Slope
80 to 110%

Relative Accuracy
pH.1* ±.1 or ±0.05% of reading, whichever is greater

pH.01* ±.01 or ±0.05% of reading, whichever is greater

mV ±1.0

Temperature ±1.0°C

Display
3 1/2 digit LCD

Inputs
BNC, pin tip

Outputs
ATC, Recorder, Power, KF

Power Requirements
Six 1.5 V AA alkaline batteries or line converter for either 110 or 220 VAC, 50/60 Hz wall outlet

Input impedance
$> 10^{12}$ ohms

Instrument drift
< 50 microvolts/°C

Input bias current
< ±1 pico amp at 25°C and < ±4 pico amps over full operating range

Environmental requirements
5 to 45°C and 5 to 80% relative humidity, non-condensing

Dimensions
Meter alone 24 X 21 X 8 cm

Meter packaged 29.2 X 29.9 X 29.9 cm

Weight
Meter alone 0.8 kg

Case
Dust and splash-resistant, chemical resistant

* After calibration with two buffers according to the procedure on page 6.

If the line converters that Orion supplies, Cat. No. 020121 and 020120, are not available, any line converter meeting the following specifications may be used.

Converter for 120V AC to 9V DC

This specification describes an AC-to-DC power supply for use with ORION Products.

Electrical Specifications

1. The power supply shall furnish rectified, filtered, unregulated DC voltage.
2. The input voltage shall be 100-130V AC, 47-63 Hz.
3. The open circuit output voltage shall not exceed 15.5V DC at an input voltage of 130V AC, 60 Hz.
4. The unit shall produce an output voltage not less than 9.0V DC with a load of 200 MADC at an input voltage of 115V AC, 60 Hz.

Mechanical Specifications

1. The power supply shall plug into two blade wall outlets that are standard in North America for 115V AC service.
2. Suggested cord length is 1.5 meters.
3. Output cord shall terminate in a standard 3.5 mm diameter phone plug. The tip shall be negative, the sleeve positive.

Safety

1. The power supply shall be UL listed and CSA approved.

Converter for 220V AC to 9V DC

This specification describes an AC-to-DC power supply for use with ORION Products.

Electrical Specifications

1. The power supply shall furnish rectified, filtered, unregulated DC voltage.
2. The input voltage shall be 200-240V AC, 47-63 Hz.
3. The open circuit output voltage shall not exceed 15.5V DC at an input voltage of 240V AC, 50 Hz.
4. The unit shall produce an output voltage not less than 9.0V DC with a load of 200 MADC at an input voltage of 220V AC, 50 Hz.

Mechanical Specifications

1. Suggested cord length is 1.5 meters.
2. Output cord shall terminate in a standard 3.5 mm diameter phone plug. The tip shall be negative, the sleeve positive.

ORION

Orion Research Incorporated
Laboratory Products Group
THE SCHRAFFT CENTER
529 MAIN STREET BOSTON MA 02129 U.S.A
TEL 617-242-3900 800-225-1480 TELEX 4430019
IN EUROPE ORION RESEARCH AG
[illegible] BRUNNENSTRASSE 3
CH-8700 KUSNACHT SWITZERLAND
TEL 01/901 [illegible] TLX 57629

Printed in U.S.A.
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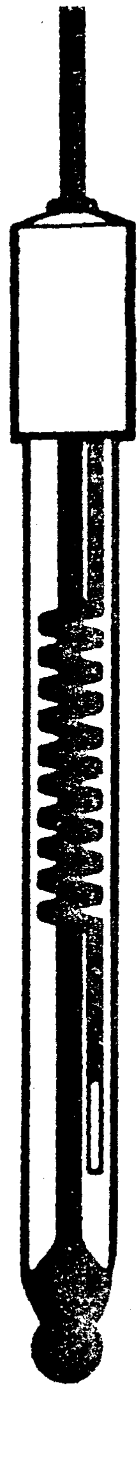


ORION
Orion Research Incorporated
Laboratory Products Group

ROSS pH ELECTRODE INSTRUCTION MANUAL

ORION
Orion Research Incorporated
Laboratory Products Groups

THE SCHRAFFT CENTER
529 MAIN STREET, BOSTON, MA 02129
TEL 800-225-1480, 617-242-3900

Printed in U.S.A. Part N. 502700-098 Form IMROSS 09/90

Models: 80-05, 81-01, 81-02, 81-03
81-04, 81-15, 81-35, 81-55
81-56, 81-63

CONTENTS

GENERAL INFORMATION

Introduction

This manual contains instructions for the ROSS® series of pH electrodes. Operation and maintenance instructions for the following electrodes are included.

Model No.	Description
80-05	ROSS Reference Half Cell, glass body
81-01	ROSS pH Half Cell, 0-14 pH, glass body
81-02	ROSS Combination pH Electrode, 0-14 pH, glass body
81-03	Semi-micro ROSS Combination pH Electrode, 0-14 pH, glass body
81-04	ROSS Combination pH Electrod 0-14 pH, glass body with rugged bulb
81-15	ROSS Semi-micro Combination pH Electrode, 0-14 pH, epoxy body
81-55	ROSS Combination pH Electrode, 0-14 pH epoxy body with bulb guard
81-56	Same as above with BNC connector
81-63	ROSS Combination Spear-tip pH Electrode, 0-14 pH, glass body

The ROSS series of electrodes provide readings stable to 0.0 pH in less than 30 seconds, even in the extreme case of samples varying from one another by 50°C or more. Results are three to five times more accurate than those obtained with conventional electrodes. And, because drift is less than 0.002 pH per day, restandardization is minimized.

ROSS Electrodes are available with various connectors. See **ORDERING INFORMATION**, or consult the Orion pH Electrode Catalog and price list. For more information contact your local ORION Distributor, or call Orion Customer Service

Required Equipment

Meter - Any ORION pH or ion selective meter, or other pH/ISE meter with appropriate connectors.

Combination pH Electrode *or* pH and Reference Electrode Half Cells - Use the ORION Model 81-01 ROSS pH Half Cell only with a ROSS Reference Half Cell Electrode, Model 80-05, or Model 80-03.

Thermometer - Readable to ± 0.5°C.

Beakers - Plastic or glass.

Magnetic Stirrer - Suggested for precision measurements.

Required Solutions

pH Buffers - Two are recommended for precise measurement. The first, near the electrode isopotential point (pH 7) and the second near the expected sample pH (e.g., pH 4 or 10).

ROSS Internal Filling Solution - 3M KCl, Orion Cat. No 810007. *Do not use any filling solution which contains silver.* (Electrode damage may result.)

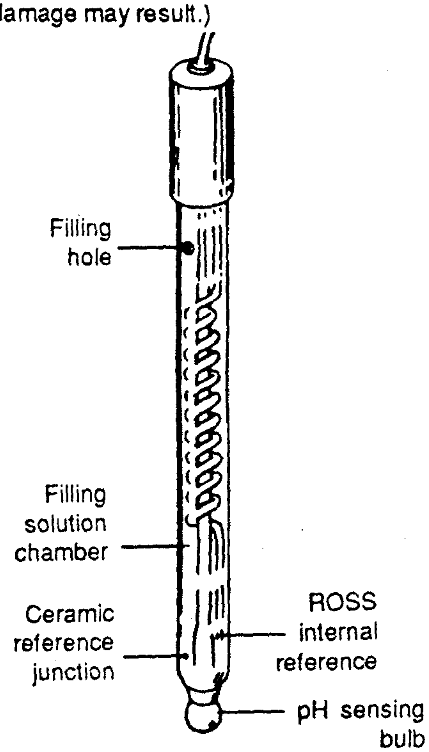


Figure 1
ROSS Combination Electrode - Cat. No. 81-02

USING THE ELECTRODE
Set up

Electrode Preparation

1. Remove the protective shipping cap from sensing element and save for storage.

2. Clean any salt deposits from exterior by rinsing wi distilled water.

3. Uncover filling hole and add ROSS Filling Solution Orion Cat. No. 810007, to electrode. See **Figure** To maintain an adequate flow rate, the level of fillir solution must always be above the reference junct and at least one inch above the sample level on immersion. The filling hole should be open whene the electrode is in use.

4. Place the electrode in the electrode holder and suspend in air for 15 minutes to thoroughly wet the reference junction. One the junction is wet, do not allow the electrode to dry out.

5. Shake down the electrode (as a clinical thermomete to remove air bubbles.

6. Soak electrode in pH Electrode Storage Solution, Orion Cat. No. 910001, for one hour. If ORION Storage Solution is not available, use 200 ml pH 7 buffer to which about 1 g KCl has been added, as a temporary substitute.

7. Connect electrode to meter.

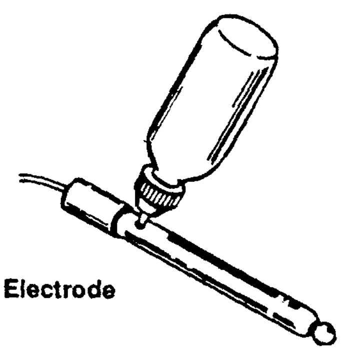


Figure 2
Filling an Electrode

Before Analysis

Sample Requirements
One of the benefits of the ROSS pH Electrode is that the filling solution composition may be changed depending on sample requirements.

The ROSS pH Electrode Filling Solution, Orion Cat. No. 810007 is 3M KCl. For solutions which precipitate in the presence of chloride ion, the ROSS pH Electrode could be filled with 10% KNO_3.

Samples should be aqueous if using epoxy body electrodes (e.g., Models 81-55 or 81-35).

In organic solutions, use an all glass ROSS Electrode. For good results a minimum of 20% water must be present in the sample. If there is a great deal of drift when using the ROSS Electrode filled with ROSS Filling Solution (Orion Cat. No. 810007), try filling the ROSS Electrode with a mixture of 2 parts methanol and 8 parts ROSS Electrode Filling Solution.

Measuring Hints See **Figure 3**

- Always use fresh buffers for calibration. Choose buffers that are no more than 3 pH units apart.
- Check electrode slope daily by performing two-buffer calibration. Slope should be 92 to 102%.
- Only use ROSS Internal Filling Solution, Orion Cat. No. 810007, for ROSS Combination pH and Reference Electrodes. Do not use any filling solution which may contain silver.
- Remove filling hole cover during measurement to ensure uniform flow of filling solution.
- Between measurements, rinse electrodes with distilled water and then with the next solution to be measured.
- Stir all buffers and samples.
- Place a piece of insulating material (e.g., styrofoam or cardboard) between magnetic stirrer and beaker to prevent error from transfer of heat to sample. Since ROSS Electrodes respond faster than conventional electrodes, changes in pH which result from temperature changes will be noticed.
- Avoid rubbing or wiping electrode bulb, to reduce chance of error due to polarization.
- Model 81-35 may be used on any moist surface or in liquids. See **Figure 4.**

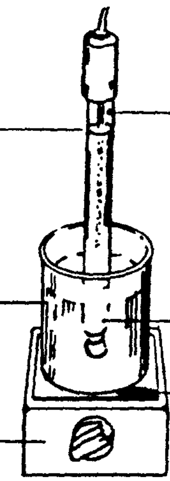


Figure 3
Measuring Hints

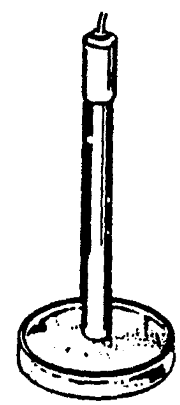


Figure 4
Use of Model 81-35

pH Calibration & Measurement

General Calibration Procedure
For detailed calibration and temperature compensation procedures, consult your meter instruction manual.

Single Buffer Calibration

1. Choose a buffer near expected sample pH.
2. Buffer should be at same temperature as sample buffer and samples are at varying temperatures, temperature compensation is recommended.
3. Set up meter according to meter instruction manual.
4. Rinse electrode first with distilled water and then with the buffer being used for calibration.
5. Place the electrode in the buffer. Wait for a stable display. Set the meter to the pH value of the buffer at its measured temperature. See **Table 1**. (A table of pH values at various temperatures is supplied on the buffer bottle.) Proceed to **pH Measurement** section.

Table 1
pH Values of Buffers at Various Temperatures

Nominal value at 25°C	Temperature 0°C	5°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C	90°C
1.68	1.67	1.67	1.67	1.67	1.68	1.69	1.71	1.72	1.74	1.77	1.79
3.78	3.86	3.84	3.82	3.79	3.77	3.75	3.75				
4.01	4.00	4.00	4.00	4.00	4.02	4.03	4.06	4.08	4.13	4.16	4.21
6.86	6.98	6.95	6.92	6.87	6.85	6.84	6.83	6.84	6.85	6.86	6.88
7.00	7.11	7.08	7.06	7.01	6.98	6.97	6.97				
7.41	7.53	7.50	7.47	7.43	7.40	7.38	7.37				
9.18	9.46	9.40	9.33	9.23	9.14	9.07	9.01	8.96	8.92	8.89	8.85
10.01	10.32	10.25	10.18	10.06	9.97	9.89	9.83				

Two Buffer Calibration

This procedure is recommended for precise measurement.

1. Ensure that all buffers are at the same temperature. If samples are at varying temperatures, temperature compensation is recommended. (See Meter Instruction Manual).
2. Select two buffers which bracket the expected sample pH. The first should be near the electrode isopotential point (pH 7) and the second near the expected sample pH (e.g., pH 4 or pH 10).
3. Rinse electrode first with distilled water and then with pH 7 buffer.
4. Place the electrode in pH 7 buffer. Wait for a stable display. Set the meter to the pH value of the buffer at its measured temperature. (A table of pH values at various temperatures is supplied on the buffer bottle). See **Table 1**.
5. Rinse electrode first with distilled water and then with the second buffer.
6. Place the electrode in the second buffer. When display is stable, set meter to the actual pH value of the buffer as described in the meter instruction manual.
7. If all steps are performed correctly, proceed to the **pH Measurement** section. If any of the above procedures does not work, refer to **Troubleshooting.**

pH Measurement

1. Calibrate the electrode as described in previous section.
2. Rinse the electrode with distilled water and then with sample.
3. Place the electrode in the sample.
4. When the display is stable, record sample pH.

Electrode Storage

To ensure a quick response and free-flowing liquid junction, the sensing element and reference junction must not be allowed to dry out.

Short-term Storage (up to one week)
Soak electrode in pH Electrode Storage Solution, Orion Cat. No. 910001. If ORION Storage Solution is not available, use about 200 ml pH 7 buffer to which about 1 gram KCl has been added, as a temporary substitute.

Long-term Storage
The reference chamber should be filled and the filling hole securely covered. Cover the sensing element and/or reference juntion with its protective cap containing a few drops of storage solution. Before returning the electrode to use, prepare it as a new electrode.

Electrode Maintenance

Weekly

1. Inspect the electrode for scratches, cracks, salt crystal build-up, or membrane/junction deposits.

2. Rinse off any salt build-up with distilled water, and remove any membrane/junction deposits as directed in the cleaning procedures below.

3. Drain the reference chamber, flush it with fresh ROSS Filling Solution, Orion Cat. No. 810007, and refill the chamber.

Cleaning Electrode
General - Soak in 0.1 M HCl or HNO_3 for half an hour, followed by soaking in storage solution for at least one hour.

Removal of Membrane/Junction Deposits
Protein - Soak in 1% pepsin in 0.1 M HCl, for 15 minutes.*

Inorganic - Soak in 0.1M tetrasodium EDTA solution for 15 minutes.*

Grease and Oil - Rinse with mild detergent or methanol solution.*

*After any of these cleaning procedures, drain and refill the reference chamber and soak the electrode in storage solution for at least one hour.

TROUBLESHOOTING

Troubleshooting Guide

Following a systematic procedure to isolate the problem The pH measuring system can be divided into four components for ease in troubleshooting: pH meter, electrodes, sample /application, and operator error.

pH meter
The meter is the component which is easiest to eliminate as a possible cause of error. ORION pH meters are provided with an instrument checkout procedure and shorting strap for convenience in troubleshooting. Consult you pH meter instruction manual for directions.

Electrodes
To test electrode operation:

1. Connect electrode to a working meter.
2. Set function switch to absolute mV mode.
3. Immerse electrode in fresh pH 7 buffer.
4. Displayed value should be 0 ±30 mV.
5. Rinse electrode and immerse in fresh pH 4 buffer.
6. Displayed value should be approximately 160 mV greater than in step 4.

If electrode fails this procedure, clean thoroughly as directed in **Maintenance.**

If electrode response is slow or drifting, drain and refill with fresh ROSS Filling Solution, Orion Cat. No. 810007. See **Measuring Hints.**

If cleaning and maintenance fail to rejuvenate the electrode:

1. For separate pH and reference half cells, substitute each electrode (one at a time) with a known working electrode and repeat test procedure. By process of elimination, determine which electrode should be replaced.
2. For combination electrodes, replace the entire electrode.

Sample/Application
The electrode and meter may operate with buffers but not with your sample. In this case, check sample composition for interferences, incompatibilities, or temperature effects.

Operator Error
If trouble persists, review operating procedures. Reread calibration and measurement sections, to be sure proper technique has been followed.

Troubleshooting (cont.)

Assistance
If after checking each component of your measuring system the source of the trouble remains unknown, call Orion's Technical Service Chemists.

In the United States (except Alaska, and Hawaii) 1-800-225-1480. In call 617-242-3900.

Elsewhere, contact your authorized Orion dealer or:

ORION RESEARCH INCORPORATED
Labora ory Products Group
The Sci,rafft Center
529 Main Street, Boston, MA 02129 U.S.A.
TLX 4430019

ELECTRODE CHARACTERISTICS

Temperature Effects

The most common cause of error in pH measurement is temperature. Ordinary electrodes drift with temperature changes. The ROSS pH Electrode eliminates the stability problems associated with the use of conventional electrodes in samples of varying temperature.

There are, however, two effects of temperature change that should be kept in mind.

1. Electrode slope will change with varying temperature. This slope change may be compensated for either manually, or automatically with an automatic temperature compensator (ATC) probe and properly designed pH meter. Consult your pH meter instruction manual for details.

2. Buffer and sample pH values vary with temperature because of their temperature dependent chemical equilibrium. The problem of differing pH values is easily solved by calibrating the electrode with characterized standard buffers whose true pH values at different temperatures are known. Buffer values at different temperatures are given in **Table 1.** The problem of the sample equilibrium varying with temperature in an uncharacterizable manner will always remain. Therefore, pH values should be reported along with the temperature at which the measurement was made.

Interferences

Sodium ion is the principle interference of the pH electrode, causing increasing error at higher pH (lower hydrogen ion activities) and at higher temperatures. Because the ROSS pH membrane is composed of special low sodium error glass, error due to sodium is negligible when measuring at pH values less than 12. When measuring at pH values greater than 12, add the correction value from the nomograph in **Figure 7** to the observed pH reading.

placement parts for the 92 and 95 Series electrodes and the 97 08 electrode (O-rings, membranes, filling solution, etc.) are warranted to be free of defects in material and workmanship for thirty (30) days from the date of shipment from Orion.

All other ORION pH electrodes, temperature probes, and compensators are warranted for one year from date of purchase.

ORION Meter and Electrode Accessories carry an "out-of-box" warranty. Should they fail to work when first used, contact Orion immediately for replacement.

Should **ORION Solutions of Buffers** be unusable when first "out-of-box," contact Orion immediately for replacement.

Series 100 Conductivity Meters and **Series 800 Dissolved Oxygen Meters** and **Dissolved Oxygen Probes** are warranted to be free from defects in material and workmanship for a period of twenty-four (24) months from the date of purchase by the user or thirty (30) months from the date of shipment from Orion, whichever is earlier; provided when used under normal laboratory conditions and in accordance with the operating limitations and maintenance procedures in the instruction manual and when not having been subjected to accident, alteration, misuse or abuse. Conductivity cells carry a one year warranty (warranty does not include coverage for broken glass cells once placed in use) from date of purchase. Dissolved Oxygen Probe Membranes carry and "out of box" warranty.

Series 100 Conductivity Cells are warranteed for one year (warranty does not cover breakage of glass cells once placed in use) from date of purchase by the user or eighteen (18) months from Date of Shipment from Orion, whichever is earlier.

Series 800 Dissolved Oxygen Probe Membranes are warranted against "out-of-box" failure.

THE WARRANTIES DESCRIBED ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES WHETHER STATUTORY, EXPRESS OR IMPLIED INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE AND ALL WARRANTIES ARISING FROM THE COURSE OF DEALING OR USAGE OF TRADE. THE BUYER'S SOLE AND EXCLUSIVE REMEDY IS FOR REPAIR OR REPLACEMENT OF THE NON-CONFORMING PRODUCT OR PART THEREOF, OR REFUND OF THE PURCHASE PRICE, BUT IN NO EVENT SHALL ORION (ITS CONTRACTORS AND SUPPLIERS OF ANY TIER) RELIABLE TO THE BUYER OR ANY PERSON FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES WHETHER THE CLAIMS ARE BASED IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE), OR OTHERWISE WITH RESPECT TO OR ARISING OUT OF THE PRODUCT FURNISHED HEREUNDER.

Representations and warranties made by any person, including its authorized dealers, representatives, and employees of Orion which alter or are in addition to the terms of this warranty shall not be binding upon Orion unless in writing and signed by one of its officers.

REMEMBER: For in- or out-of-warranty repair or service, contact Orion Product Service. Product Service will issue a Return Authorization (RA) for all warranty services. You must have an Orion RA prior to returning/forwarding any product to Orion.

ORDERING INFORMATION

Electrodes

ROSS Electrodes are available with a variety of connectors. For more information, consult your ORION pH Electrode Catalog and price list or your local ORION Distributor.

Model Number	Description	Type of Connector
800500	ROSS Reference Half Cell, glass body	Pin-tip
810100	ROSS pH Half Cell, glass body	U.S. Std.
8101BN	Same as above	BNC
810200	ROSS Combination pH Electrode, glass body	U.S. Std.
8102BN	Same as above	BNC
810300	Semimicro ROSS pH Electrode, glass body	U.S. Std.
8103BN	Same as above	BNC
810400	ROSS Combination pH Electrode, glass body with rugged bulb	U.S. Std.
8104BN	Same as above	BNC
811500	Semimicro ROSS Combination pH Electrode, epoxy body	U.S. Std.
8115BN	Same as above	BNC
813500	ROSS Combination Flat Surface pH Electrode, Epoxy body	U.S. Std.
8135 BN	Same as above	BNC
815500	ROSS Combination pH Electrode, epoxy body with bulb guard	U.S. Std.
815600	Same as above	BNC
816300	ROSS Combination Spear-tip pH Electrode, glass body	U.S. Std.
8163BN	Same as above	BNC

Accessories

Cat. No.	Description
810002	pH Solutions Bulk Pack for use with ROSS pH Electrodes. Contains: two 50 ml bottles ROSS pH Electrode Internal Filling Solution, one 475 ml bottle of Electrode Storage Solution, four 475 ml bottles of pH 7.00 Buffer, four 475 ml bottles of 10.1 Buffer, three flip-top spout dispensers, and instruction sheet
810007	ROSS Internal Filling Solution, 3M KCl, five 50 ml bottles
910001	pH Electrode Storage Solution, 475 ml
910104	pH 4.01 Buffer, 475 ml
910107	pH 7.00 Buffer, 475 ml
910110	pH 10.01 Buffer, 475 ml

SPECIFICATIONS

Electrode*	Length (excluding cap)	Diameter
80-05	120 mm	12 mm
81-01	120 mm	12 mm
81-02	120 mm	12 mm
81-03	165 mm	6 mm
81-04	120 mm	12 mm
81-15	165 mm	6 mm
81-35	120 mm	12 mm
81-55	120 mm	12 mm
81-56	120 mm	12 mm
81-63	110 mm	5 mm (tip)

* ROSS Electrodes operate in a 0-100°C temperature range, 0-14 pH range

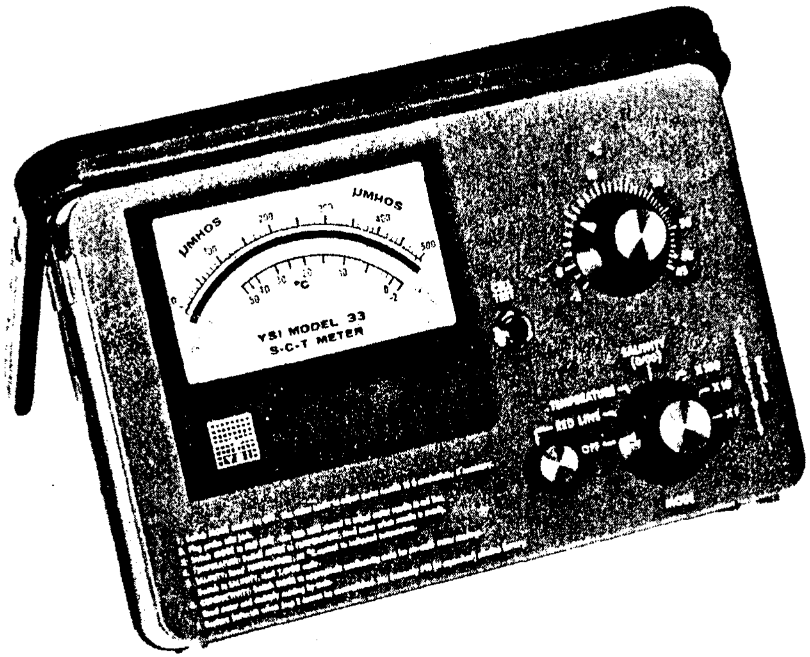
Isopotential points are at pH 7

Standard cap diameters are 16mm and cap lengths are 30mm

APPENDIX E

OPERATIONS MANUAL FOR YELLOW SPRINGS MODEL 33 CONDUCTIVITY/TEMPERATURE METER

INSTRUCTIONS FOR YSI MODEL 33 AND 33M S-C-T METERS



Scientific Division
Yellow Springs Instrument Co., Inc.
Yellow Springs, Ohio 45387 • Phone 513-767-7241

PRICE INCLUDING HANDLING $5.00

TABLE OF CONTENTS

GENERAL DESCRIPTION

The YSI Model 33 and 33M S-C-T Meters are portable, battery powered, transistorized instruments designed to accurately measure salinity, conductivity and temperature. They use a probe consisting of a rugged, plastic conductivity cell and a precision YSI thermistor temperature sensor combined in a single unit.

Conductivity with the Model 33 is expressed as micromhos/centimeter (μmhos/cm); with the 33M, it's millisiemens/meter (mS/m). These are measurements of the electrical conductance the sample would show if measured between opposite faces of a 1cm cube. (Conversion information: 1 μmho/cm = 0.1 mS/m.) Salinity is the number of grams of salt/kilogram of sample (‰ = parts per thousand). This measurement assumes the sample contains a "standard" sea water salt mixture. The sample temperature is measured in degrees Celsius.

Salinity measurements are manually temperature compensated by direct dial. Conductivity measurements are not temperature compensated; however, a temperature function is provided on the instrument to aid with calculation of corrections. Also, when just temperature and conductivity are known it is possible to calculate salinity, and when only temperature and salinity are known it is possible to calculate conductivity.

SPECIFICATIONS

Model 33 Conductivity

Ranges:	0-500, 0-5,000, 0-50,000 μmhos/cm with YSI 3300 Series Probes. (Note: The "μmho" designations on the meter are a shorthand form for "μmho/cm".)
Accuracy:	±2.5% max. error at 500, 5,000 and 50,000 plus probe. ±3.0% max. error at 250, 2,500 and 25,000 plus probe. See Error Section.

Readability:	2.5 μmhos/cm on 500 μmho/cm range. 25 μmhos/cm on 5,000 μmho/cm range. 250 μmhos/cm on 50,000 μmho/cm range.
Temperature Compensation:	None

Model 33M Conductivity

Ranges:	0-50, 0-500, 0-5,000 mS/m with YSI 3300 Series Probes.
Accuracy:	±2.5% max. error at 50, 500, and 5,000 plus probe. ±3.0% max. error at 25, 250, and 2,500 plus probe. See Error Section.
Readability:	0.25 mS/m on 50 mS/m range. 2.5 mS/m on 500 mS/m range. 25.0 mS/m on 5,000 mS/m range.
Temperature Compensation:	None.

Salinity

Range:	0-40 ‰ in temperature range of -2 to +45°C.
Accuracy:	Above 4°C, ±0.9 ‰ at 40 ‰ and ±0.7 ‰ at 20 ‰ plus conductivity probe. Below 4°C, ±1.1 ‰ at 40 ‰ and ±0.9 ‰ at 20 ‰ plus conductivity probe. See Error Section.
Readability:	0 2 ‰ on 0-40 ‰ range.
Temperature Compensation:	Manual by direct dial from -2 to +45°C.

Temperature

Range:	-2 to +50°C.
Accuracy:	±0.1°C at -2°C, ±0.6°C at 45°C plus probe. See Error Section.
Readability:	±0.15°C at -2°C to ±0.37°C at 45°C.

Power Supply	Two D-size alkaline batteries. Eveready E95 or equivalent, provide approximately 200 hrs. of operation.
Probe	YSI 3300 Series Conductivity/Temperature Probe. Nominal Probe Constant: K = 5/cm
Accuracy:	±2% of reading for conductivity and salinity. Error of ±0.1°C at 0°C and ±0.3°C at 40°C.

Instrument

Ambient Range:	Satisfactory operation -5 to +45°C. A maximum error of ±0.1% of the reading per °C change in instrument temperature can occur. This error is negligible if the instrument is readjusted to redline for each reading.

OPERATION PROCEDURE

1. **Setup**
   (a) Adjust meter zero (if necessary) by turning the bakelite screw on the meter face so that the meter needle coincides with the zero on the conductivity scale.
   (b) Calibrate the meter by turning the MODE control to REDLINE and adjusting the REDLINE control so the meter

needle lines up with the redline on the meter face. If this cannot be accomplished, replace the batteries.
   (c) Plug the probe into the probe jack on the side of the instrument.
   (d) Put the probe in the solution to be measured. (See Probe Use.)

2. **Temperature**
   Set the MODE control to TEMPERATURE. Read the temperature on the bottom scale of the meter in degrees Celsius. Allow time for the probe temperature to come to equilibrium with that of the water before reading.

3. **Salinity**
   (a) Transfer the temperature reading from Step 2 to the °C scale on the instrument.
   (b) Switch the MODE control to the SALINITY position and read salinity on the red 0-40 ‰ meter range.
   (c) Depress the CELL TEST button. The meter reading should fall less than 2%; if greater, the probe is fouled and the measurement is in error. Clean the probe and re-measure.

4. **Conductivity on Model 33 (Model 33M data are in parentheses.)**
   (a) Switch the MODE control to the X100 scale. If the reading is below 50 on the 0-500 range (5.0 on the 0-50 range), switch to the X10 scale. If the reading is still below 50 (5.0), switch to the X1 scale. Read the meter scale and multiply the reading appropriately. The answer is expressed in µmhos/cm (mS/m). Measurements are not temperature compensated.

Example:	Meter Reading:	247 (24.7)
	Scale:	X10
	Answer:	2470 µmhos/cm (247.0 mS/m)

(b) When measuring on the X100 and X10 scales, depress the CELL TEST button. The meter reading should fall less than 2%; if greater, the probe is fouled and the measurement is in error. Clean the probe and re-measure.

NOTE: The CELL TEST does not function on the X1 scale.

5. **Error**

The maximum error in a reading can be calculated by using the graphs in the following sections.

(1) Temperature

The temperature scale is designed to give the minimum salinity error when the temperature readings are used to compensate salinity measurements.

Figure 1 shows total error for probe and instrument versus °C meter reading.

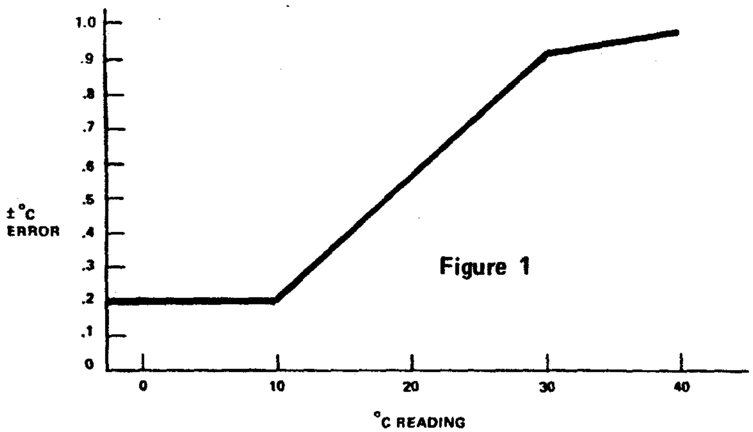


Figure 1

Example:	Meter Reading:	15°C
	Total Error:	0.4°C
	Accuracy:	15°C ± 0.4°C for probe and instrument combined

(2) Conductivity on Model 33 (Model 33M data are in parentheses.)

Figure 2 shows the worst-case conductivity error as a function of the conductivity reading for the probe and instrument combined.

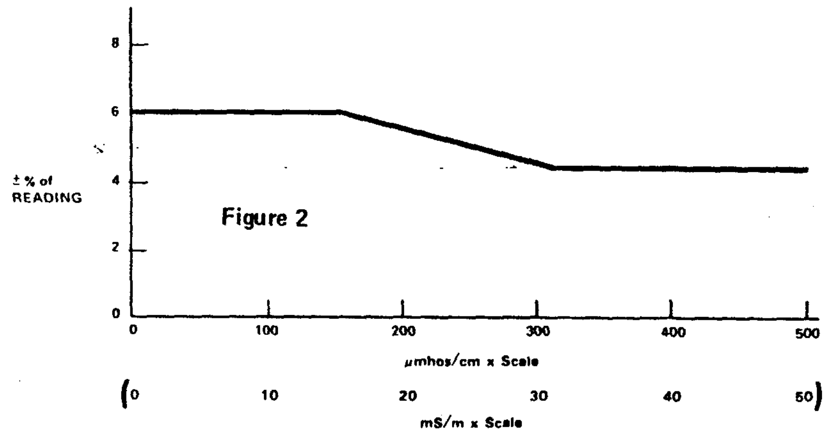


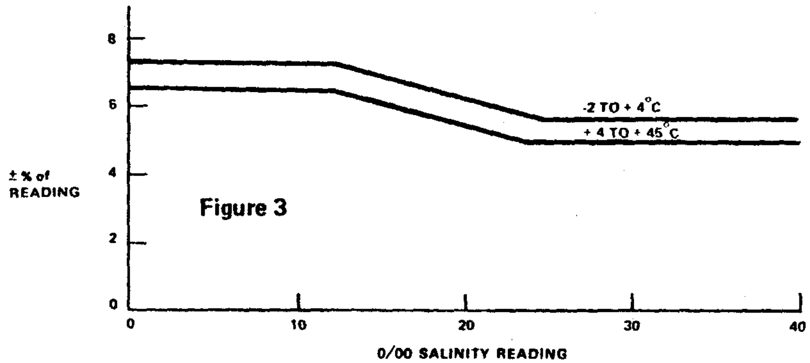
Figure 2

Example:	Meter Reading:	360 μmhos/cm (36 mS/m)
	Scale:	X10
	% Reading Error:	± 4.5%
	Accuracy:	3600 ±162 μmhos/cm (360 ±16.2 mS/m) for probe and instrument

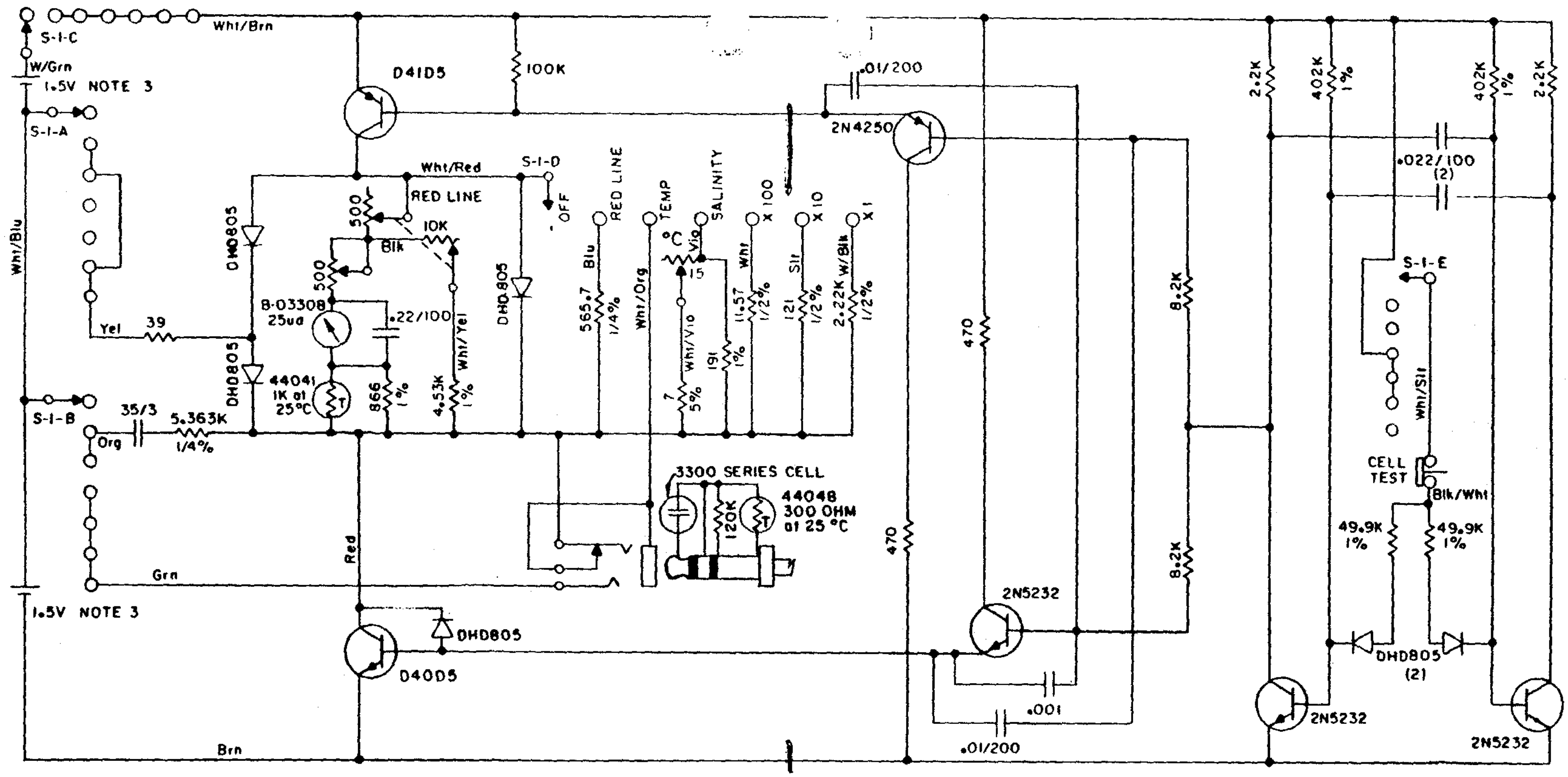
(3) Salinity

The salinity readings are a function of temperature and conductivity, therefore the accuracy is a function of both.

The temperature scale and temperature control have been designed to minimize the temperature error contribution to the salinity error. The error shown in Figure 3 is the total of the temperature and conductivity probe, the temperature scale and the salinity scale error.



Example:	Meter Reading:	10 0/00, @ 10°C
	% of Reading Error:	6.5%
	Accuracy:	10 ‰ ± 0.65 ‰ for all errors, combined worst case.



NOTE:

1. Resistance values in ohms, K=1,000; resistors are ¼W, 10% unless otherwise specified.
2. The values shown on the schematic may differ from those in the instrument; if so, either value can be used for replacement purposes.
3. Battery is "D" size, alkaline only, Eveready E-95 or equal.

YSI MODEL 33 AND 33M B-03321-F

CIRCUIT DESCRIPTION, MAINTENANCE AND CALIBRATION

1. Description

The circuit is composed of two parts; a multivibrator and switching transistors. The multivibrator produces a square waveform voltage. The square wave is applied to two switching transistors. They alternately apply two batteries of opposite polarity to the probe thus providing AC power which minimizes polarization effects. The meter is in series with one battery and measures the current from it. The current from the battery is proportional to the conductance of the cell. Salinity is measured in a special range conductivity circuit which includes a user-adjusted temperature compensator. In the temperature, redline and X1 positions the multivibrator operates at 100 Hz. In the salinity, X100 and X10 positions the multivibrator operates at 600 Hz and in these ranges pushing the CELL TEST button drops the frequency to 100 Hz allowing the operator to judge the degree of probe polarization.

2. Maintenance

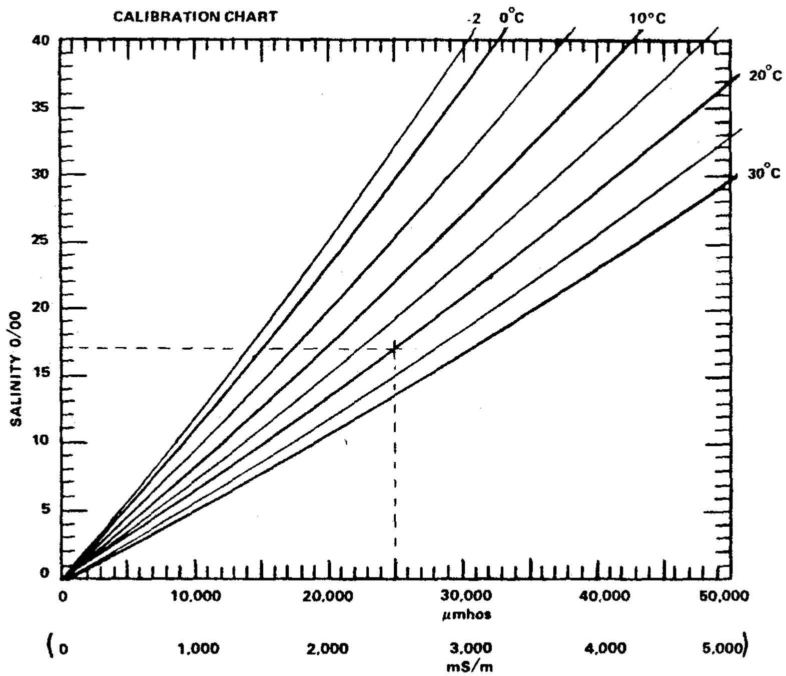
The only maintenance required is battery replacement. Two "D" size alkaline flashlight cells, such as Eveready E95 or equivalent, will provide 200 hrs. of operation. Accuracy will not be maintained if zinc-carbon "D" cells are used. Battery replacement is indicated when the redline adjustment cannot be accomplished.

Replace batteries every six months to reduce the danger of corrosion due to leaky batteries. To replace batteries, remove the six screws from the rear plate. The battery holders are color coded. The Positive (+ button) end must go on red.

3. Calibration of Model 33 (Model 33M data are in parentheses.)

It is possible for the temperature knob to become loose or slip from its normal position. In an emergency the dial can be re-positioned. It must be emphasized that this is an emergency procedure only, and that the instrument should be returned to the factory for proper recalibration at the earliest opportunity.

(a) Read the temperature and conductivity of the solution. Determine the salinity of the solution by running a line vertically on the graph from this conductance value until it intersects the appropriate °C line (interpolate as required for temperature between the given °C lines). From this intersection extend a



line horizontally to the edge of the graph. This determines the salinity for this sample.
Example: 25,000 μmhos/cm and 20°C gives a salinity of 17. (Example: 2,500 mS/m and 20°C gives a salinity of 17.)

(b) Remove the °C knob, switch to SALINITY, and turn the control shaft until the meter needle indicates the salinity value determined in Step (a). In the example given, the value is 17.

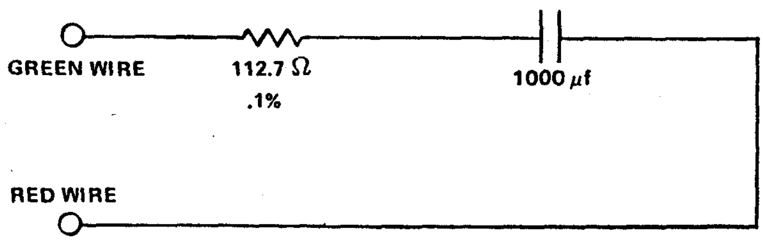
(c) Switch to TEMPERATURE. (Note: This temperature reading must be the same as Step (a); if not, begin again at Step (a).) Place the knob on the control shaft (without turning the control shaft) with the knob pointer at the same temperature as the meter reading and tighten both set screws securely.

At earliest opportunity recalibrate using the following procedure or return the instrument to factory for service.

(a) Set the instrument for a salinity measurement as normal.

(b) Substitute a 1000 μf capacitor and 112.7 ohm 0.1% tolerance resistor for the probe.

Connect the resistor and capacitor between the green wire and red wire on the jack connections inside the instrument.



(c) Turn the temperature dial until the meter reads redline.

Now install the temperature knob with the arrow at 25°C. This is a temporary calibration only. Return the instrument to the factory for proper recalibration.

PROBE

1. Description of YSI 3300 Series Conductivity/Temperature Probe

The YSI 3300 Series Conductivity Probes are designed for field use, embodying construction and design for rugged, accurate service.

Each probe features a built-in cell constant of 5.0 (500.0/M) ±2%, a precision YSI thermistor temperature sensor of ±0.1°C accuracy at 0°C and ±0.3°C at 40°C and a low capacitance cable assembly terminating in a three terminal 0.25" dia. phone type connector.

The 3310 has a 10 ft. cable and the 3311 is a 50 ft. version. Other lengths are available on special order.

The probe has a rigid P.V.C. body, platinized pure nickel electrodes, and a durable cable, providing resistance to a wide range of water-borne substances.

2. Maintenance

(a) Cleaning

When the cell test indicates low readings the probable cause is dirty electrodes. Hard water deposits, oils and organic matter are the most likely contaminants.

For convenient normal cleaning soak the electrodes for 5 minutes with a locally available bathroom tile cleaning preparation such as: Dow Chemical "Bathroom Cleaner"; Horizon Industries "Rally, Tile, Porcelain, and Chrome Cleaner"; Johnson Wax "Envy, Instant Cleaner"; or Lysol Brand "Basin, Tub, Tile Cleaner."

or stronger cleaning a 5 minute soak in a solution made of 10 parts distilled water, 10 parts isopropyl alcohol and 1 part HCl can be used.

Always rinse the probe after cleaning and before storage.

CAUTION: Do not touch the electrodes inside the probe.
Platinum black is soft and can be scraped off.

If cleaning does not restore the probe performance, re-platinizing is required.

(b) Re-Platinizing

Equipment Required —

(1) YSI #3140 Platinizing Solution, 2 fl. oz. (3% platinum chloride dissolved in 0.025% lead acetate solution).
(2) YSI Model 33 or 33M S-C-T Meter.
(3) 50 ml glass breaker or equivalent bottle.
(4) Distilled water.

Procedure —

(1) Clean the probe as in Section (a) — either method.
(2) Place the cell in the beaker and add sufficient YSI #3140 solution to cover the electrodes. Do not cover the top of the probe.
(3) Plug the probe into the Model 33 or 33M, switch to the X100 scale to platinize the electrode. Move the probe slightly to obtain the highest meter reading and continue platinizing for the approximate time shown below:

Meter Reading μ**mhos/cm**	**mS/m**	**Time (minutes)**
30,000	3,000	5
25,000	2,500	6
20,000	2,000	8
15,000	1,500	11
10,000	1,000	16

(4) After the elapsed time remove the probe and rinse in fresh water.
(5) Return the solution to its container. 2 oz. of solution should be sufficient for 50 treatments.

(c) Storage:
It is best to store conductivity cells in deionized water. Cells stored in water require less frequent platinization. Any cell that has been stored dry should be soaked in deionized water for 24 hours before use.

3. Probe Use

(a) Obstructions near the probe can disturb readings. At least two inches of clearance must be allowed from non-metallic underwater objects. Metallic objects such as piers or weights should be kept at least 6 inches from the probe.

(b) Weights are attached to the cable of the YSI 3310 and 3311 Probes. The YSI 3327 Weights are supplied in pairs with a total weight of 4 ounces per pair. Should it become necessary to add more weight to overcome water currents, we suggest limiting the total weight to two pounds (8 pairs). For weights in excess of two pounds use an independent suspension cable. In either case, weights must be kept at least 6 inches away from the probe.

(c) Gentle agitation by raising and lowering the probe several times during a measurement insures flow of specimen solution through the probe and improves the time response of the temperature sensor.

4. Cell Calibration & Standard Solutions

The YSI #3300 Series Cells are calibrated to absolute accuracy of ±1.5% based on a standard solution. Since the literature on conductivity does not indicate a consistently accepted standardization method, we have chosen the 0.01 demal KCl solution method as determined by Jones and Bradshaw in 1937 as our standard. Recent textbooks, as well as the ASTM standards, concur with this choice.

The solution is prepared by diluting 0.745 grams of pure dry KCl with distilled water until the solution is 1 kilogram. The table below shows the values of conductivity this solution would have if the distilled water were non-conductive. However, since even high purity distilled water is slightly conductive, the measured conductivity will be higher by an amount equal to the water's conductivity.

	Conductivity	
Temperature °C	μmhos/cm	mS/m
15	1141.5	114.2
16	1167.5	116.8
17	1193.6	119.4
18	1219.9	122.0
19	1246.4	124.6
20	1273.0	127.3
21	1299.7	130.0
22	1326.6	132.7
23	1353.6	135.4
24	1380.8	138.1
25	1408.1	140.8
26	1436.5	143.7
27	1463.2	146.3
28	1490.9	149.1
29	1518.7	151.9
30	1546.7	154.7

The operator may use the standard solution and the table to check accuracy of a cell's constant or to determine an unknown constant. The formula is shown below:

$$K = \frac{R\,(C_1 + C_2)}{10^6} \quad \text{or} \quad \frac{R\,(S_1 + S_2)}{10^5}$$

where: K = Cell constant
R = Measured resistance in Ω

C_1 = Conductivity in μmhos/cm
C_2 = Conductivity in μmhos/cm of the distilled water used to make solution.
S_1 = Conductivity in mS/m
S_2 = Conductivity in mS/m of the distilled water used to make the solution.

R, C_1 and C_2, or S_1 and S_2, must either be determined at the same temperature or corrected to the same temperature to make the equation valid.

Note: For further information on conductivity and the above standard information, refer to ASTM Standards Part 23 — Standard Methods of Test for Electrical Conductivity, or Water and Industrial Waste Water — ASTM Designation D1125-64.

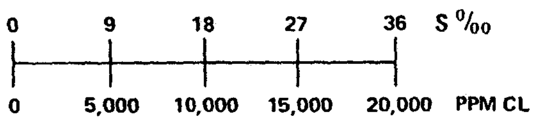
YSI MODEL 33 AND 33M USED WITH YSI 51A, 54 and 57 OXYGEN METERS

If the salinity measurement is to be used for salinity correction on the 51A, the reading should be converted to Chlorosity. The formula is:

$$\text{PPM Chlorosity} = \frac{\text{Salinity } ‰ - 0.03}{1.8} \times 10^3$$

For these instruments the 0.03 can be neglected so the equation simplifies to:

$$\text{PPM Cl} = \frac{\text{SS } ‰ \times 10^3}{1.8}$$



For salinity correction when using the Model 57 use the salinity reading direct from the Model 33 or 33M. No conversion is necessary.

Model 33 and 33M salinity readings taken in conjunction with Model 54 dissolved oxygen readings can be used to correct the Model 54 for salinity and to make post-measurement salinity corrections to dissolved oxygen data. Correction tables are available from the factory.

WARRANTY

All YSI products carry a one-year warranty on workmanship and parts, exclusive of batteries. Damage through accident, misuse, or tampering will be repaired at a nominal charge.

If you are experiencing difficulty with any YSI product, it may be returned to an authorized YSI dealer for repair, even if the warranty has expired. If you need factory assistance for any reason, contact:

Service Department
Yellow Springs Instrument Co., Inc.
P.O. Box 279
Yellow Springs, Ohio U.S.A.
Phone: (513) 767-7241

to a conductance meter. The cell is rinsed with a small quantity of Calibrator Solution, which is then discarded. The cell is immersed in the Calibrator Solution in the flask. After two minutes of stirring, the solution temperature is measured with a ±0.1°C thermometer and found to be 22.1°C. From the equation, the conductivity of the Calibrator Solution is then calculated as follows:

Using the YSI 3163 Calibrator Solution

Calibration Solution Conductivity = 10,000 X [0.5538 + (0.0168)(22.1) + (0.000042) (22.1²)2] = 9,456 µSiemens/cm

The tolerance of the Calibrator Solution at this temperature is ±0.35%. The conductance meter reading is 9,200 µSiemens. Therefore, the cell constant is calculated as follows:

$$\text{Cell Constant} = \frac{9{,}456\ \mu\text{Siemens/cm}}{9{,}200\ \mu\text{Siemens/cm}} = 1.028 \pm 0.0036/\text{cm}$$

When a groundwater specimen yields a meter reading of 4,000 µSiemens the actual conductivity is:

Specimen Conductivity = *4,000 µSiemens x 1.028/cm = 4,112 ±14* µSiemens/cm

There is an additional error depending on the uncertainty in the measurement of the temperature. In general, this error is approximately an additional ±0.2% for each 0.1°C uncertainty in the temperature. In the example, if it is assumed that the temperature is 22.1 ±0.1°C, then the cell constant is 1.028 ±0.0057/cm.

Storage

Store below 30°C (86°F) to minimize the likelihood of error due to evaporation of water or to microbial growth. Do not freeze; the bottle may break. If a container does freeze, thaw it completely and mix the contents *before removing any solution.* Discard if expiration date is past, or if color, turbidity, or visible microbial growth develops. Since the iodine used for initial disinfection of these solutions will lose potency on standing, solutions which have been opened are not secure against microbial invasion, and must *be discarded within one month of opening.*

Safety

These solutions are nonflammable, unreactive and are believed to be of a very low order of toxicity. However, swallowing large amounts of potassium salts may lead to cardiac arrhythmias. If swallowed, induce vomiting. If splashed in the eye, rinse the eye thoroughly with clean water. Although precautions have been taken to exclude microorganisms from these products, they are not sold as medically sterile.

Metrology

This solution is referenced to a primary reference solution in a constant temperature bath in which the temperature is uniform, stable and controlled. A conductivity cell, constructed of platinum and chemically resistant glass, similar in design to that used by Jones and Bradshaw (J. Am. Chem. Soc. 55,

1780-1800[1933]), is connected by four wires (to avoid lead resistance effects) to a 4 1/2 digit conductance meter of established stability and linearity. The cell constant is chosen so as to keep the measured conductance between approximately 1,000 and 10,000µSiemens to minimize error due to shunt or series impedances. The cell and meter are only transfer standards; the primary reference solution is the fundamental reference.

Primary reference solutions are prepared according to the recommendation (IR No. 56-1981) of the Organisation Internationale de Metrologie Legale (OIML). The OIML recommendation is the recognized international reference. This recommendation is substantially consistent with ASTM Standard Test Method D1125-77.

Potassium chloride (NIST SRM 999, National Institute of Standards and Technology) is dried for five hours at 500°C after which the purity is at least 99.98%. Taking the potassium chloride as 100%, on the basis that the impurities are salts of similar conductivity, a specified mass (corrected to vacuo) is dissolved in distilled, deionized water to yield 1,000.00 grams of solution (corrected to vacuo). The initial conductivity of the distilled water equilibrated to atmospheric CO_2, approximately 1.3 µSiemens/cm, is then added to the value tabulated below to obtain the assigned conductivity of the primary reference solution.

gKCl per Kg Solution	Conductivity at 25.00°C
71.1352	111,310 µSiemens/cm
7.41913	12,852 µSiemens/cm
0.745263	1,408.3 µSiemens /cm

The primary reference solution nearest in conductivity to each YSI Conductivity Calibrator Solution is used to inspect that solution. Allowance is made at the time of manufacture for a slight increase in conductivity as the iodine is reduced to iodide. This solution will be within stated tolerances at both the beginning and the end of the shelf life interval.

Warranty

All YSI products are warranted for one year or until the expiration date against defects in materials and workmanship when used for their intended purpose and maintained according to instructions. Contact your dealer for warranty service.

YSI Incorporated
Yellow Springs Instrument Co., Inc, Yellow Springs, Ohio 45387 USA
Phone 513 767-7241•800 765-4974•Fax 513 767-9353•Telex 205437

Item 062068 PART A03464 D

YSI Conductivity Calibrator Solutions Instructions

YSI conductivity Calibrator Solutions are secondary standard solutions for the calibration of conductivity cells together with conductance meters. The solutions are provided in two ranges of accuracy. The YSI 3161, 3163, and 3165 solutions are made to close tolerances and intended primarily for use in laboratory applications where other factors which strongly influence conductivity can also be tightly controlled or accurately measured. The YSI 3167-3169 solutions are made to less exacting tolerances and are intended mainly for use in field applications where other factors are less subject to close control or measurement.

YSI Conductivity Calibrator Solution

YSI Number	Size	Conductivity in µSiemens at 25°C	Tolerances at 25°C
3161	1 US Quart	1,000	±0.50%
3163	1 US Quart	10,000	±0.25%
3165	1 US Quart	100,000	±0.25%
3167	8 x 1 US Pt	1,000	±1.0%
3168	8 x 1 US Pt	10,000	±1.0%
3169	8 x 1 US Pt	50,000	±1.0%

Units of Measure

Resistance = Ohms = Ω Conductance = siemens = S = mho

1 US Gallon = 3.785 L 1 US Quart = 0.9462 L

Conductance = 1/Resistance = Ω^{-1}

1 S/m = 0.01 mhos/cm = 10,000 µSiemens/cm

1,000,000 µSiemens = 1,000 mmhos = 1 mho

Solution Conductivity = Conductance x Cell Constant = 1/Resistivity

YSI Incorporated
Yellow Springs Instrument Co., Inc, Yellow Springs, Ohio 45387 USA
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Directions for Use

Clean and rinse the cells before calibration, then season them in the Calibrator Solution. Minimize evaporation of the Calibrator Solution when calibrating; use a narrow-necked vessel or cover the vessel with plastic kitchen wrap. Avoid carrying contaminants in with cells being calibrated - the effect of this is cumulative. Do not introduce anything into the original container of Calibrator Solution, as this may inoculate the solution with microbes. Heavily platinized cells, or cells of complex geometry may require more than two minutes to achieve stable readings. Check the calibration of the bath or thermometer. At high conductance, contact resistance between the meter and probe can be a source of error. Make this connection as solid as possible. Do not get grease on electrode surfaces. It is very important that the electrodes be thoroughly wetted before use. See conductivity cell instructions.

Temperature has a large effect on conductivity. Calibration should be performed as close as practical to 25°C, preferably with a water bath to control temperature. If room temperature is stable and between 20°C and 30°C, the calibrator may be thermally equilibrated with the room, and then the temperature may be measured at the moment of calibration to an accuracy of ±0.1°C, or as precisely as possible. Electrically compensated readings may be taken on instruments so equipped. This may be less accurate because the temperature coefficient of the compensator may not match that of the solution, the circuitry of the compensator may introduce additional sources of electrical error, and because of the uncertainty in the temperature measurement. If the compensator is adjustable, set it to 1.9%/°C for YSI 3161 or 3163, and for 3167 and 3168 solutions; and to 1.8%/°C for YSI 3165 and 3169 solutions. To minimize compensator errors, calibrate at a temperature as close as possible to 25.00°C.

Dip Cells: Select a glass or plastic container several inches taller than the working part of the cell and at least two inches greater in diameter. Clean and dry this container, then fill it with calibrator solution to a depth at least two inches greater than the working part of the cell. Rinse the cell by pouring a little calibrator solution into and over it. Connect the cell to the conductance meter and immerse the cell in the calibrator solution. For approximately two minutes, stir the solution intermittently with the cell and move the cell up and down to force liquid through it. Take care to purge the cell of bubbles. Position the cell in the approximate center of the calibrator solution, and at least one inch from any wall or from the surface of the solution. Record the temperature reading and record (or adjust) the conductance meter reading.

Flow Cells: Purge the cell by passing ten to twenty times its own volume of Conductivity Calibrator Solution through it. (The volume of any connecting tubing or fittings must be considered part of the cell volume for this operation.) When the cell temperature is stable, record the temperature and record or adjust the conductance meter reading. Micro cells may give high readings if the solution is completely stagnant-maintain some flow of solution through the cell during calibration, preferably the same rate of flow that would be used to measure an unknown solution.

Fill Cells: Fill and empty the cell at least three times with the Conductivity Calibrator Solution. When the cell temperature is stable (allow at least two minutes), record the temperature and record or adjust the conductance meter reading. When calibration is complete, rinse and store the cell in distilled water or in a dilute solution of HCl or KCl. Used Conductivity Calibrator Solution must be regarded as contaminated and should not be returned to its original container.

Calculations

If the calibration was performed at 25.00°C or is ostensibly corrected to 25.00°C, the meter reading for the calibration solution should have been the nominal 25.00°C value of 1,000, 10,000, 50,000 or 100,000 µSiemens/cm. Adjustable meters can be trimmed to agree exactly with the nominal value of the calibrator solution. If the meter is not adjustable, or is to be used with several different probes, calculate a cell constant or a correction factor as follows:

$$\text{Cell Constant} = \frac{\text{Actual Calibrator Solution Conductivity}}{\text{Conductance Meter Reading}}$$

Conductivity readings on unknown solutions with this cell and meter may then be taken according to :

Solution Conductivity = (Conductance Meter Reading) x (Cell Constant)

For meters which presume a cell constant (not necessarily a round number) and give a reading in conductivity, it is more practical to calculate a correction factor by the formula:

$$\text{Correction Factor} = F = \frac{\text{Actual Calibrator Solution Conductivity}}{\text{Conductivity Meter Reading}}$$

Unknown solution readings are then corrected by:

Correct Conductivity = F x Meter Reading

Note that meter calibration is a factor in all these readings. Unless meters are accurately calibrated, different cell Constants or correction factors will be obtained from the same cell and solution with different meters, or even on different ranges of the same meter. For independent calibration of conductance meters, use the YSI 3166 Conductance and Resistance Calibrator Set; if the instrument in use is the YSI Model 3000 TLC Meter, use the YSI 3040 Test Probe. If meters are not independently calibrated, the cell constant or correction factor calibrated above will apply only to the very cell, meter, range and mode (for meters which read in both ohms and Siemens or mhos) used in the calibration. Calibrate each cell in each range and each mode for best results.

When calibrating without temperature compensation at a temperature other than 25.00°C, you must factor into the equations given above the Calibrator Solution conductivity *at the temperature of calibration* instead of the nominal 25.00°C value. See the discussion of **Temperature Effects**, below.

Apart from errors due to conductance meter calibration, cell constants may vary slightly with conductivity and with cell history. Calibration should therefore be undertaken with a Calibrator Solution as near in value as possible to the value of the unknown solutions to be measured. For unknowns of very low conductivity use the 1,000 µSiemens/cm Calibrator Solutions.

Calibrator values lower than 1,000 µSiemens/cm would be unstable and are not well documented. Recalibrate at six-month intervals, or following any visible change in cell condition. Cell fouling, cleaning or replatinization may have a substantial effect on cell constants, as will any mechanical bending or displacement of the electrodes.

Temperature Effects

The conductivity of the Calibrator Solutions at various temperatures may be calculated from the following equation:

Conductivity = (Conductivity at 25.00°C) x $(A + Bt + Ct^2)$
where t = temperature in °C (ITPS68)

Conductivity at 25.00°C	A	B	C
1,000 µSiemens/cm	0.5407	0.0173	0.000043
10,000 µSiemens/cm	0.5538	0.0168	0.000042
100,000 µSiemens/cm	0.5825	0.0157	0.000040

The conductivity may be obtained by using the following table for the YSI 3161 to 3165 solutions:

TEMP	3161	3163	3165
20°C	904 µSiemens/cm	9,066 µSiemens/cm	91,260 µSiemens/cm
21°C	923 µSiemens/cm	9,251 µSiemens/cm	92,980 µSiemens/cm
22°C	942 µSiemens/cm	9,437 µSiemens/cm	94,730 µSiemens/cm
23°C	961 µSiemens/cm	9,624 µSiemens/cm	96,480 µSiemens/cm
24°C	981 µSiemens/cm	9,812 µSiemens/cm	98,230 µSiemens/cm
25°C	1,000 µSiemens/cm	10,000 µSiemens/cm	100,000 µSiemens/cm
26°C	1,020 µSiemens/cm	10,190 µSiemens/cm	101,800 µSiemens/cm
27°C	1,039 µSiemens/cm	10,380 µSiemens/cm	103,600 µSiemens/cm
28°C	1,059 µSiemens/cm	10,570 µSiemens/cm	105,400 µSiemens/cm
29°C	1,079 µSiemens/cm	10,760 µSiemens/cm	107,100 µSiemens/cm
30°C	1,098 µSiemens/cm	10,960 µSiemens/cm	109,000 µSiemens/cm

Numerical Examples

It is desired to measure the conductivity of groundwater which is expected to be in a range between 3,000 and 8,000 µSiemens at 25°C. A 10,000 µSiemens/cm Calibrator Solution is selected for this example. About 900 ml of solution is poured into a clean and dry 1,000 ml Erlenmeyer flask. The flask and its contents are equilibrated to room temperature. A dip cell is connected

APPENDIX F

OPERATIONS MANUAL FOR HACH MODEL 16800 TURBIDITY METER

40298-00

Instruction Manual

PORTALAB TURBIDIMETER
Model 16800

7-1-86-8ED

CONTENTS

ILLUSTRATIONS

™Trademark of Hach Company

SPECIFICATIONS

Ranges	0-1 NTU 0-10 NTU 0-100 NTU
Method of Detection	Nephelometric
Repeatability	±1% of full scale
Smallest Scale Division	1% of full scale on all ranges
Readability	0.005 NTU on lowest range
Linearity	Better than 2% on 1, 10 and 100 ranges
Response Time	Less than 5 seconds on lowest range; less than 1 second on highest range
Temperature Considerations	Operating Temp. (includes charging): 10° to 50°C, Storage Temp: 0° to 60°C
Stray Light	Less than 0.04 NTU on two lowest ranges Less than 0.5 NTU on the highest range
Calibration	Based on formazin
Standardization	Set of Gelex secondary turbidity standards of known value furnished
Sample Required	Approximately 18 ml
Sample Cell	18 × 115 mm flat-bottom glass vial
Meter	Mirrored 4½ inch. Calibrated in 3 NTU ranges
Light Source	Lens-end tungsten lamp. Lamp life in excess of 3,000 hours
Sensor	Silicon photocell
Power Requirements	Self-contained, 6-volt, NiCd battery pack. Battery life approximately 10 hours/charge for over 300 charges. Charge time of 12-16 hours
Recorder Output	100 mV full scale. Recorder input impedance 10K ohms or greater
Case	Durable black ABS plastic; resistant to impact and chemical attack
Dimensions	14 × 10¾ × 8½ inches (35.5 × 27.3 × 21.6 cm)
Weight	Net: 10 lbs (4.5 kg); Shipping: 14 lbs (6.3 kg)

SAFETY PRECAUTIONS

NOTICE

Before attempting to unpack, set up and operate this equipment, please read this entire manual. Pay particular attention to all warnings, cautions and notes. Failure to do so could result in serious injury to the operator or damage to the equipment.

Use of Warnings, Cautions and Notes

Warnings, cautions and notes used in this manual have the following significance:

WARNING

Failure to observe this information can result in personal injury or loss of life.

CAUTION

Failure to observe this information can result in damage to equipment.

NOTE

Information that requires special emphasis

Precautionary Labels

Please pay particular attention to labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

CERTIFICATION

Hach Company certifies that this instrument was tested and inspected thoroughly and found to meet its published specifications when it was shipped from the factory.

PORTALAB TURBIDIMETER
Model 16800

DESCRIPTION

General

The Hach Model 16800 PortaLab Turbidimeter (Figure 1) is designed for use in the field as well as the laboratory. Turbidity values in the ranges of 0-1.0, 0-10, and 0-100 nephelometric turbidity units (NTU) can be measured in a variety of liquids. A recorder output of 100 mV full scale is available at a jack on the instrument panel. The instrument operates on battery power supplied by a rechargeable nickel-cadmium battery pack. The battery pack, located in the bottom of the carrying case, provides power to make measurements in remote locations before the samples deteriorate. All the necessary accessories are conveniently stored in the carrying case.

Accessories

Accessory items supplied with the turbidimeter are described in the following paragraphs. Most of the items are stored in the foam insert just below the control panel for easy access. The battery charger will normally be left in the laboratory, leaving space in the foam insert for the beaker. The wash bottle should be carried separately.

Sample Cells

Three sample cells are included with the instrument and are stored in the foam insert. The cells are 18 × 115 mm, Pyrex® glass. A white line marks the 18-ml volume used in these measurements, and a white dot provides a point of reference so that the cell can be placed in the cell holder with the same rotational orientation each time.

®Pyrex is a trademark of Corning Glass Works.

1 LIGHT SHIELD
2 FOCUSING TEMPLATE
3 CELL RISER
4 BATTERY CHARGER
5 RECORDER PLUG
6 TURBIDITY STANDARDS
7 SILICONE OIL
8 WASH BOTTLE
9 SAMPLE CELLS
10 BEAKER

FIGURE 1 MODEL 16800 PORTALAB TURBIDIMETER

Sample cells should be clean and free of fingerprints, and any water droplets on the outside surface should be wiped dry. When surfaces become scratched or nicked, the cells should be discarded.

Turbidity Standards

A set of three Gelex® secondary turbidity standards, one for each range, is supplied with the turbidimeter. Also included in this standardization kit is a methanol stray light standard.

Care should be taken to protect the surfaces from nicks and scratches as they cause light to scatter and indicate false turbidity.

Nominal values of the three Gelex standards are 0.9 NTU, 9 NTU and 90 NTU. Because of minor variations in individual instruments and glass vials, the readings you get with these standards may differ slightly from the value stated. Therefore, Hach recommends the instrument be calibrated with Formazin primary standards and then the secondary standards be measured to identify any variations from the nominal values. If there are differences, the actual values should be marked on the vials and these actual values used in subsequent standardizations.

Focusing Template

The focusing template is used to align and focus the light beam and also to block light from the photocell detector when zeroing the instrument. The device has a translucent disc containing a focusing circle that reveals any misalignment of the lamp or lens.

Cell Riser

When measuring turbidities in the 100-NTU range, the cell riser is placed into the cell holder before the sample cell is inserted to decrease the light path through the sample. This is necessary to keep good linearity when measuring solutions with high turbidity. Measurements in the two lower ranges require the longer light path so the cell riser must not be used in those ranges.

Battery Charger

The battery charger supplied with the instrument (Hach Battery Charger, Cat. No. 17058) can be used with either 115 Vac or 220 Vac by moving the voltage selector to the proper setting.

The charger will restore the battery pack to a full charge in 12 to 16 hours.

CAUTION

The battery charger should not be used to operate the instrument on ac power. On models before serial number 721, any attempt to operate the instrument with the battery charger plugged in may result in damage to the charger. Subsequent instruments will not operate while the charging jack is in the instrument.

It is recommended that the charger be stored at the laboratory where the recharging operation is performed to allow more space in the carrying case for test apparatus and reagents.

Light Shield

The light shield is used to cover the sample or standard while it is being measured. The shield must be in place when the reading is taken to prevent interference from ambient light.

Recorder Plug

A phono plug is furnished to mate with the recorder output jack located on the control panel. The plug must be installed on the customer's recorder input cable with the positive lead connected to the tip terminal and the negative lead connected to the ring terminal.

Labware

The plastic beaker and wash bottle are included for sample dilution in the event sample turbidities exceed 100 NTU. Because demineralized water could dissolve some of the turbidity, filtered sample should be used as the dilution water. *Refer to Operational Notes.*

Silicone Oil

A light film of silicone oil on the outside surfaces of the sample cell will minimize the effects of minor scratches or other imperfections in the glass. Light reflections from these imperfections, if detected by the photocell, will read as turbidity, thus introducing a positive error. This is particularly evident when measuring very low turbidities. Sample cells that are scratched extensively should be replaced.

Controls and Indicators

Figure 2 illustrates the control panel features. In the following paragraphs, the function of each control, indicator and connector is described.

Meter

A 4½-inch meter with a mirrored scale is used. The scale is calibrated in three separate ranges: 0 to 1.0, 0 to 10, and 0 to 100 NTU. A battery check area is also designated to indicate the condition of the battery pack during the battery test.

SPAN *Control*

This control is used during standardization of the

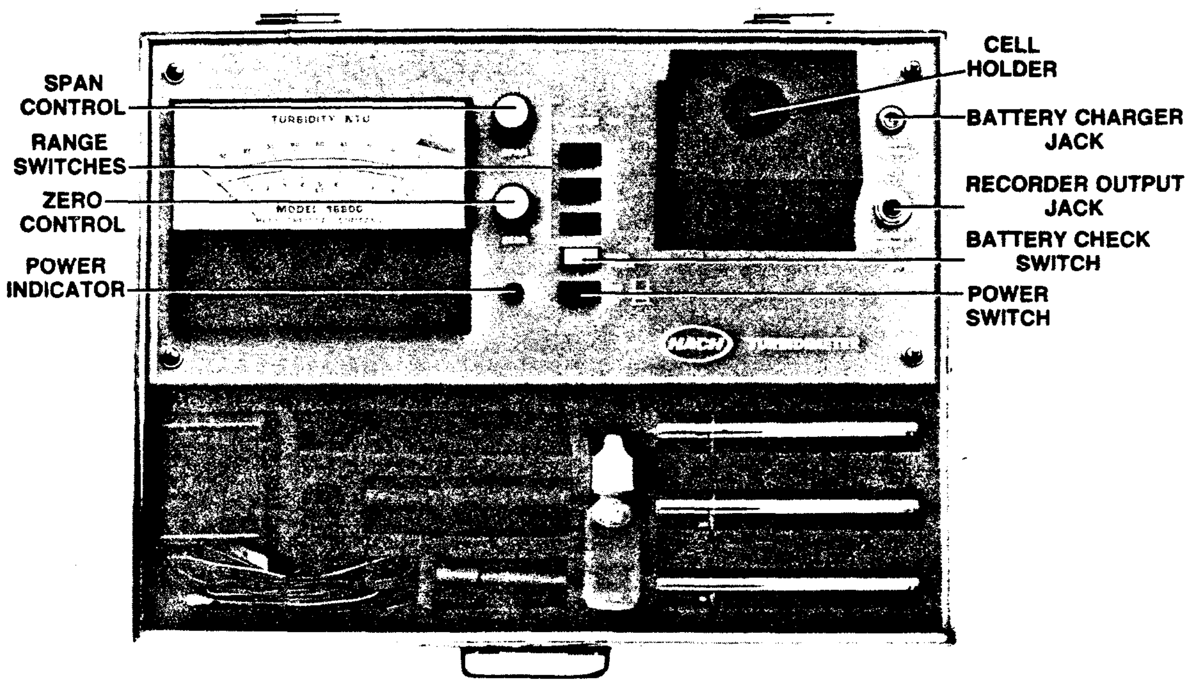


FIGURE 2 **CONTROL PANEL FEATURES**

instrument. After the instrument has been zeroed, the turbidity standard is placed into the instrument and the SPAN control is adjusted to obtain a reading equal to the value of the standard.

ZERO *Control*

Prior to each measurement, the instrument must be zeroed electronically before the test sample is placed in the cell holder. The focusing template is inserted into the cell holder to block light to the photocell and the ZERO control is used to obtain a zero NTU reading on the meter.

RANGE *Switches*

Three pushbutton range switches provide a means of selecting the desired NTU range. As each switch is pressed, the switch activated previously is released.

BATT CHECK *Switch*

This switch is used to perform a check of the battery pack. It is a momentary switch and must be held down until the meter needle stabilizes. The power switch must be on (down) for the battery test.

Power Switch

This switch turns on power to the instrument. The switch is pressed down to turn on power and pressed again to release it and turn the power off.

Power Indicator

This light emitting diode indicates when the power switch is on (down). It is part of the wiring harness.

BATTERY CHARGER *Jack*

The battery charging unit is connected to this jack during charging operations. Be sure the charger voltage selector switch is positioned properly before plugging the unit into the wall receptacle.

RECORDER OUTPUT *Jack*

A 0 to 100 millivolt recorder output is available at this jack. A mating plug is supplied with the turbidimeter and must be installed on the customer's recorder input cable. The recorder input impedance must be 10 kilohms or greater.

PRINCIPLE OF OPERATION

The design of the Model 16800 Turbidimeter is that of a true nephelometer. *See Figure 3.* As such, the instrument is highly sensitive for measuring small amounts of turbidity and has a linear and direct response to increases in turbidity. In this instrument, the light beam enters the sample through the bottom of the sample cell and passes up through the sample and into the light shield whose black interior acts as a light trap to help minimize stray light. As the light passes through the sample, some light is scattered by turbidity in the sample. A portion of that light scattered at 90 degrees is sensed by the photocell and the resulting photocell output is conditioned to drive the instrument meter. The meter scale is calibrated in

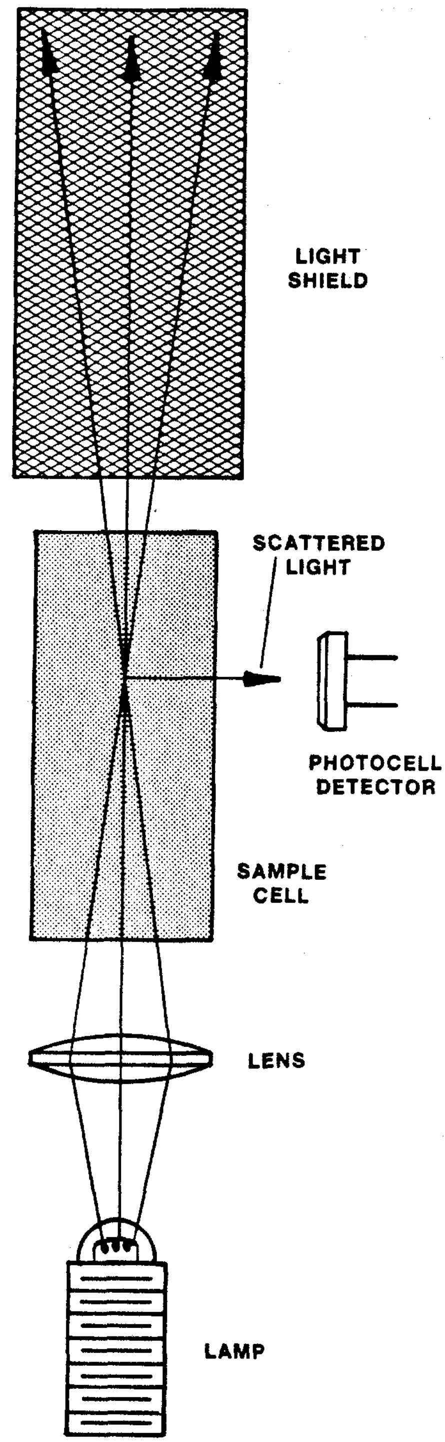


FIGURE 3 LIGHT PATH DIAGRAM

nephelometric turbidity units to provide direct turbidity readouts. The light source is a lens-end tungsten lamp with a usable life of approximately 3000 hours. The detector is a silicon photocell.

Operating power is supplied by a battery pack that contains five D-size nickel-cadmium batteries connected in series to provide 6.25 Vdc. The batteries can be recharged approximately 300 times and each charge provides about 10 hours of normal use.

NOTE

The response of any turbidimeter to a test sample is directly dependent on the physical design features (i.e., light source, detector, optics, electronics, etc.) of the instrument. It should be noted that whenever the physical design of any two turbidimeters differ, a sample may not read the same turbidity value on the two instruments even when both were calibrated with Formazin.

OPERATION

Standardization Procedure

To ensure consistently accurate results, perform standardization before each set of tests.

1. Turn the instrument off and check the mechanical zero setting. Adjust the screwdriver adjustment control on the meter face if necessary to obtain a zero-NTU reading.
2. Press the power switch to ON and perform a battery check by pressing the BATT CHECK switch and verifying that the meter indicates in the BATTERY CHECK area. If not, charge the battery pack.
3. Place the focusing template into the cell holder. The focusing template will block all light from reaching the detector and allow the instrument to be zeroed electronically in Steps 4 and 5.
4. Press the 1.0 range switch and adjust the ZERO control for a reading of zero NTU.
5. Press the 10 range switch and verify that the meter still indicates zero NTU. Readjust the ZERO control if necessary.
6. Remove the focusing template and place the 9-NTU turbidity standard into the cell holder. Use the black dot on the standard vial to orient the vessel in the same position each time, thereby eliminating variations due to rotation.
7. Place the light shield over the turbidity standard and allow the meter to stabilize.
8. Adjust the SPAN control for a reading of 9 NTU. Remove the light shield and turbidity standard. The instrument is now ready for use.

Taking the Turbidity Measurement

1. Ensure that the instrument has been standardized recently and that the SPAN control has not been changed since standardization. With the instrument turned off, check the mechanical zero setting.
2. Press the power switch and BATT CHECK

switch and verify that the meter indicates within the BATTERY CHECK area. If it does not, recharge the battery pack.

3. Press the appropriate range switch. Select the range that will exceed the expected turbidity of the sample under test.
4. Place the focusing template into the cell holder and adjust the ZERO control for a reading of zero NTU. Remove the focusing template. **Note:** If the instrument will be used in the 100 range, place the cell riser into the cell holder before inserting the test sample. When using the 1 and 10 ranges, the cell riser must not be used.
5. Fill a clean sample cell to the white line with the sample to be measured and place it into the cell holder. Use the white dot on the sample cell to orient the cell in the same position each time. Cover the sample cell with the light shield and allow the meter to stabilize. Read the turbidity of the sample.

Operational Notes

1. The sample size for all turbidity measurements should be 18 ml. Use the line on the sample cell as a level indicator. Variations in sample volume can affect the accuracy of the determinations.
2. When measuring the lower ranges (0-10 and 0-1 NTU), air bubbles in the sample will cause false high readings. Before covering the cell with the light shield, observe the sample in its cell. If finely divided air bubbles are present, five minutes may be required before the bubbles can rise past the photocell so that a valid reading can be taken.
3. If a water sample being tested is supersaturated with oxygen, air bubbles may appear on the sides of the sample cell in sufficient numbers to prevent turbidity measurement. This problem can be corrected by placing a drop of membrane-filtered Triton® X-100 Solution in the cell before filling with the water sample.
4. When measuring high amounts of turbidity, it may be necessary to dilute the sample in order to bring it within the range of the instrument. If the sample is extremely turbid or highly colored, the meter may read less than the actual amount of turbidity present. When a sample appears to contain more turbidity than the meter reads, the sample should be diluted with another portion of sample that has been filtered. Diluting with distilled or deionized water may dissolve some of the turbidity. The remeasured turbidity of the diluted sample should then be multiplied by the dilution factor to obtain the turbidity of the original sample. If the accuracy of the reading is still questionable, further dilutions should be conducted.
5. The connection for the 0-100 mV recorder output must be made with the three-circuit plug provided with the instrument and must be wired so that the tip terminal connects to the positive recorder input terminal and the ring terminal connects to the negative recorder input terminal.
6. When operating the instrument under bright ambient light conditions, protect the detector between measurements by inserting the focusing template or covering the cell holder with the light shield.

*Triton is a trademark of Rohm and Haas Co.

MAINTENANCE

Charging The Battery Pack

The battery pack life is approximately ten hours per charge and can be recharged more than 300 times. The battery pack will reach full charge in 12 to 16 hours. Overnight charging the night before the instrument is to be used is recommended.

CAUTION

Do not close the lid of the carrying case while using the battery charger. This practice can short circuit the charging cord, resulting in considerable damage to the internal circuitry of the instrument.

Lamp Alignment and Focusing

The lamp image is focused at the factory with the aid of the focusing template furnished with the instrument. Inside the template are two plastic discs that define the target circle. When the template is placed in the cell holder assembly, the properly focused instrument will show the image of the lamp within the target circle. The image should be centered in the target circle and should occupy about one half of the area within the target circle. If the image is not centered, or is too small or too large, readjustment should be made as follows:

1. Remove the four mounting screws from the front panel.
2. Lift the panel from the case and place it face up on a protective mat.
3. Install the focusing template and press the power button to turn on the instrument.
4. View from above, through the focusing tem-

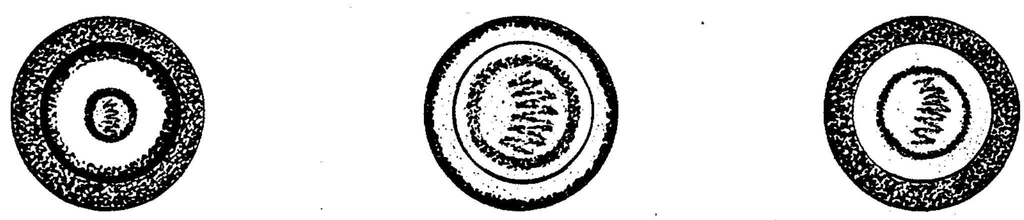


FIGURE 4 **INSTRUMENT FOCUSING**

plate opening. The image should be centered in the circle. If it is not, loosen the two lamp adjusting screws located on the lamp mount. *See Figure 5.*

5. Position the lamp holder plate to center the lamp image; then retighten the two lamp adjusting screws.
   If the image can not be centered precisely, it must at least lie within the target circle.
6. If the lamp image is too large or too small in relation to the target circle, the lens assembly needs adjustment. *See Figure 4.* Loosen the lens assembly thumbscrew *(see Figure 5)* and adjust vertically until the image is close to the correct example in Figure 4. Be careful not to leave fingerprints on the lens.
   NOTE: Variations in the filament image will not affect the performance of the instrument.

   For optimum performance, the filament image should be centered as much as possible and it should occupy about half of the area within the target circle.
7. Reinstall the panel in the instrument case.

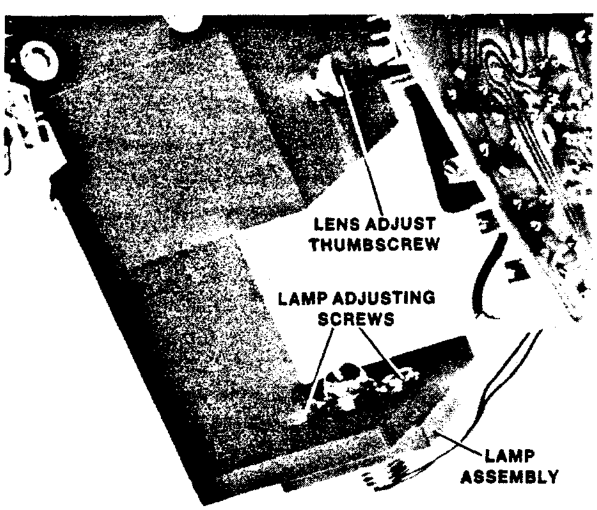


FIGURE 5 **FOCUSING ADJUSTMENTS**

Calibration Standards

Calibration of this instrument is based on Formazin, a polymer whose light-scattering properties can be reproduced accurately and precisely. The highly irregular surfaces of the formazin polymer particle partially accounts for its good reproducibility and makes it a very efficient scatterer of light on a weight percent basis. The unit of measure used in this instrument is the Nephelometric Turbidity Unit (NTU), referring to the method of measurement.

Preparing Turbidity Standards

The following formula for preparing a Formazin stock suspension rated at 4000 NTU is provided for those investigators who demand the utmost in accuracy or who may want to check the value of their secondary turbidity standard. A more convenient, prepared 4000-NTU turbidity standard can be purchased from Hach under Cat. No. 2461-11.

1. Dissolve 5.000 grams of reagent grade hydrazine sulfate ($N_2H_4 \cdot H_2SO_4$) in about 400 ml of distilled water.
2. Dissolve 50.000 grams of pure hexamethylenetetramine in about 400 ml of distilled water.
3. Pour the two solutions into a one-liter volumetric flask and dilute to volume with distilled water.
4. Allow the solution to stand for 48 hours at 20°-22°C (68°-72°F). During this time the suspension will develop. This is a 4000 NTU stock solution.

The following table gives the dilutions for preparing 100, 10, and 1.0-NTU solutions from the 4000-NTU stock suspension. When diluting the suspension, use "turbidity-free"* distilled or demineralized water. Be sure to adequately mix the stock suspension prior to removing a portion for dilution.

*Refer to "Correcting For Turbidity of Dilution Water."

ml Stock Suspension	Diluted to	NTU Value
5 ml of 4000-NTU	200 ml	100
20 ml of 100-NTU	200 ml	10
15 ml of 10-NTU	200 ml	0.75

Correcting For Turbidity of Dilution Water

There will always be a residual turbidity even in the purest water. At the 1-NTU level, this can have a significant effect on the value of the Formazin standard. The 0.75-NTU Formazin standard for the 0-1 range can be corrected for the turbidity of the dilution water by the following procedure:

1. Make a nominal 0.75-NTU Formazin standard by diluting 15 ml of 10-NTU Formazin to 200 ml with turbidity-free water.
2. Standardize the turbidimeter at 0.75 NTU on the 1.0 range.
3. Measure and record the turbidity of the dilution water used in preparing the 0.75-NTU standard. It must be less than 0.25 NTU or the combined turbidity of the Formazin stock and dilution water will exceed the top of the 1.0 range.
4. Calculate the actual NTU value of the nominal 0.75-NTU standard using the following equation:

$$T = (A/B)(T_s) + (1-A/B)(T_w)$$

where
A = volume of stock solution
B = total diluted volume
T_s = turbidity of stock solution
T_w = turbidity of dilution water

For example, if the dilution water used in Step 1 had a turbidity of 0.15 NTU, then

$A = 15$
$B = 200$
$T_s = 10$
$T_w = 0.15$

The corrected value of the nominal 0.75-NTU standard would be:

$T = (15/200)(10) + (1 - 15/200)(0.15)$
$T = 0.75 + 0.14$
$T = 0.89$ NTU

5. Standardize the turbidimeter at the corrected value (0.89 NTU) in the 0-1 range.

Preparing Turbidity Standards with Digital Titrator

The Hach Digital Titrator can be used to prepare convenient and precise turbidity standards as an alternate method for checking the accuracy of the turbidimeter or the secondary turbidity standards supplied with the instrument. A digital titrator Formazin cartridge, rated at 4000 NTU, is available that can be used to make suitable dilutions for checking each range of the turbidimeter.In the following procedures, dilutions rated at 100 NTU, 10 NTU, and 1 NTU are prepared.

1. Prepare approximately 800 ml turbidity-free water by filtering demineralized water through a 0.45-micron membrane filter.
2. Shake the 4000-NTU Formazin cartridge vigorously to mix the Formazin suspension. Shake for 1 minute.
3. If using the titrator in the hand-held position, attach a clean, straight-stem delivery tube to the cartridge. Twist the cartridge onto the titrator body. If the titrator is to be used on a laboratory stand, use a clean, 90-degree delivery tube.
4. Flush the delivery tube by turning the coarse delivery knob to eject a few drops of Formazin. Reset the counter to zero and wipe the tip.
5. Select the appropriate standard concentration from the options below and prepare the dilution as described. Then fill a clean sample cell to the mark with the standard and use it to check the accuracy of the turbidimeter or secondary standard.

   100-NTU Standard—Dispense 1000 digits of Formazin into a clean, Class A, 50.0-ml volumetric flask. Dilute to the mark with turbidity-free water and mix well.

   10-NTU Standard—Dispense 100 digits of Formazin into a clean, Class A, 50.0-ml volumetric flask. Dilute to the mark with turbidity-free water and mix well.

   1-NTU Standard—NOTE: There will be a residual amount of turbidity in even the purest water used to make Formazin dilutions. At the 1 NTU level this can significantly affect the value of the Formazin standard, causing a positive error. The following procedure corrects for the turbidity of the dilution water when making a 1 NTU Formazin standard in a 500.0-ml, Class A volumetric flask.

   a. Standardize the turbidimeter with a secondary standard on a range appropriate for the measurement of the dilution water, usually 0-1 NTU range.
   b. Measure and record the turbidity of the dilution water to be used in making the 1 NTU Formazin standard.
   c. Calculate the number of digits necessary to dispense the proper amount of Formazin

into a 500.0-ml, Class A volumetric flask for a 1 NTU Formazin standard:

$$DIGITS = 100\,(1 - T_w)$$

where T_w is the turbidity of the dilution water.

d. Dispense the calculated number of digits into a 500.0-ml volumetric flask. Slowly turn the fine delivery knob until the proper number of digits is reached. Dilute with dilution water to the 500.0-ml mark and mix well.

NOTE: The following formula may be used to determine the correct number of digits necessary to dispense Formazin for a standard of any value:

$$DIGITS = (0.2)(V)(T_D - T_w)$$

where T_D = desired turbidity of Formazin standard

T_w = turbidity of dilution water. Term may be dropped if it is 1% or less than T_D

V = volume of flask in ml

Example 1: One liter of a 0.5 NTU Formazin standard is desired. It is found that the dilution water has a turbidity of 0.05 NTU. Since the dilution water turbidity is 10% of the desired standard, the dilution water correction must be made.

The number of digits of Formazin is equal to:

$$DIGITS = (0.2)(1000.0)(0.5 - 0.05) = 90$$

Thus, 90 digits of Formazin dispensed in a 1000.0-ml, Class A volumetric flask and diluted to volume with 0.05 NTU water will give a 0.5 NTU Formazin standard.

The size of the volumetric flask should be chosen so that the number of digits calculated is approximately 100 or more.

Range Calibration Check

Each range is calibrated at the factory but should be checked from time to time against fresh Formazin turbidity standard dilutions. *Refer to the Calibration Standards paragraph for instructions for preparing standards.* Three trimmer potentiometers on the amplifier circuit board provide an adjustment for each range. Check each range *as described in the following procedure* and make the appropriate adjustments when necessary, using the procedures *described in Range Calibration.*

1. With the instrument turned off, check the mechanical zero adjustment on the meter face. Adjust for a zero reading if necessary.
2. Turn the instrument on and perform a battery check. Charge the battery pack if the meter indicates below the BATTERY CHECK area.
3. Place the focusing template into the cell holder, press the 1.0 range switch, and adjust the ZERO control to obtain a zero NTU reading.
4. Remove the focusing template and insert a 0.75-NTU turbidity standard. Adjust the SPAN control for a corrected 0.75-NTU reading.
5. Remove the 0.75-NTU standard and replace it with a 10-NTU standard. Press the 10 range switch. The meter should indicate 10 (±0.2) NTU. If it does not, the 10 range potentiometer needs adjustment *as described in the Range Calibration procedure.* Adjust the SPAN control for a reading of exactly 10 NTU.
6. Remove the 10-NTU standard and replace it with the cell riser and 100-NTU standard. Press the 100 range switch. The meter should indicate 100 (±2) NTU. If it does not, the 100 range potentiometer needs adjustment *as described in the Range Calibration procedure.*
7. Remove the 100-NTU standard and cell riser and insert the 10-NTU standard. Press the 10-NTU range switch. Adjust the SPAN control for a reading of exactly 10 NTU.
8. Remove the 10-NTU standard and replace it with a 0.75-NTU standard. Press the 1.0 range switch. The meter should indicate the corrected value for the 0.75-NTU standard (±0.02). If it does not, the 1.0 range potentiometer needs adjustment *as described in the Range Calibration procedure.*

Range Calibration

In the event the range adjustment potentiometers on the amplifier circuit board require adjustment, remove the instrument from its case and proceed as follows:

1. With the instrument turned off, check the meter's mechanical zero adjustment. Adjust for a zero reading if necessary.
2. Turn on power and perform a battery check. Charge the battery pack if the meter indicates below the BATTERY CHECK area.
3. Place the focusing template into the cell holder, press the 1.0 range switch and adjust the SPAN control fully counterclockwise.
4. Adjust the ZERO control clockwise to obtain a 0.05-NTU reading on the 1.0 scale.

5. Adjust the SPAN control clockwise to obtain a reading of 0.15-NTU on the 1.0 scale. Do not alter the SPAN control setting for the remainder of this procedure.
6. Press the 100 range switch and adjust the ZERO control for a zero reading.
7. Remove the focusing template and insert the cell riser and 100-NTU Formazin turbidity standard. Cover the standard with the light shield and allow the meter to stabilize. Adjust the 100 range adjustment potentiometer to obtain a full-scale reading. *See Figure 6.*
8. Remove the 100-NTU standard and cell riser and insert the focusing template into the cell holder.
9. Press the 10 range switch and adjust the ZERO control for a zero reading.
10. Remove the focusing template and substitute the 10-NTU Formazin standard. Cover with the light shield and allow the meter to stabilize. Adjust the 10 range adjustment potentiometer to obtain a full-scale reading.
11. Remove the 10-NTU standard and insert the focusing template.
12. Press the 1.0 range switch and adjust the ZERO control for a zero reading.
13. Remove the focusing template and insert the 0.75-NTU Formazin turbidity standard. Cover with the light shield and allow the meter to stabilize. Adjust the 1.0 range adjustment potentiometer to obtain a reading equal to the corrected NTU value determined when adding the turbidity of the dilution water to the nominal value of the standard. *Refer to "Correcting For Turbidity of Dilution Water."*

Cleaning

Other than the sample cells themselves, the only optical surfaces that require occasional cleaning are those of the lens. The lens assembly is located in the bottom of the cell holder assembly and is accessible from the underside of the panel. A plastic thumbscrew holds the lens assembly in the cell holder. To remove the lens for cleaning, loosen the thumbscrew and lower the lens assembly out of the cell holder. *See Figure 5.* The lens surfaces can then be wiped clean, or if desired, the lens can be removed from its holder and cleaned more thoroughly. Use a cloth or tissue that will not leave an oil film on the glass.

When replacing the lens assembly, place it in the cell holder with the screw heads showing. The instrument must now be focused *as described in the Lamp Alignment and Focusing procedure.*

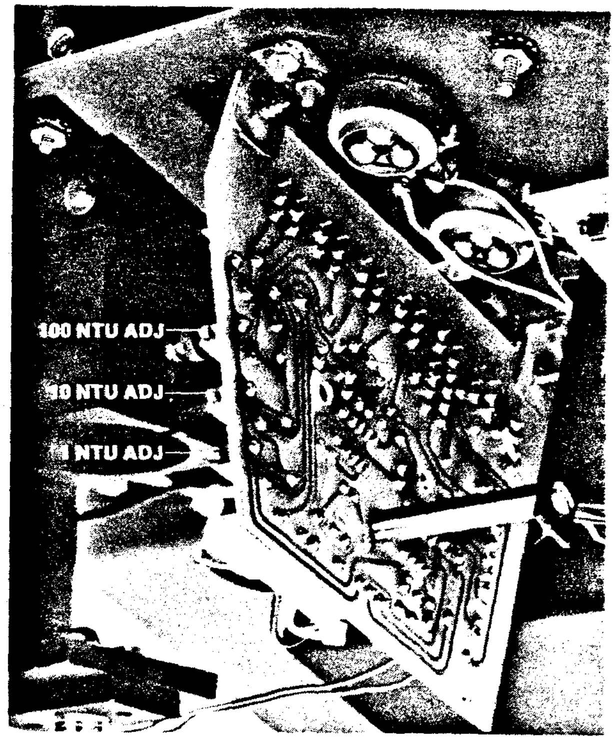


FIGURE 6 RANGE ADJUSTMENTS

Battery Replacement

Five size D batteries supply operating power in the Model 16800 Portalab Turbidimeter. Replace the battery pack as follows:

1. Remove the four mounting screws from the front panel.
2. Lift the panel from the case and place it face down on a protective mat.
3. Remove the four mounting nuts and washers that hold the battery cover to the panel. *See Figure 7.*
4. Remove the battery pack from the cover and disconnect the two wires from the battery terminals.
5. Connect the new battery pack to the two wires, red to the positive terminal and black to the negative terminal.
6. Perform a battery check. If the proper meter deflection is obtained, reassemble the instrument. If not, charge the battery pack and recheck the batteries.

Lamp Replacement

1. Remove the four mounting screws from the front panel.

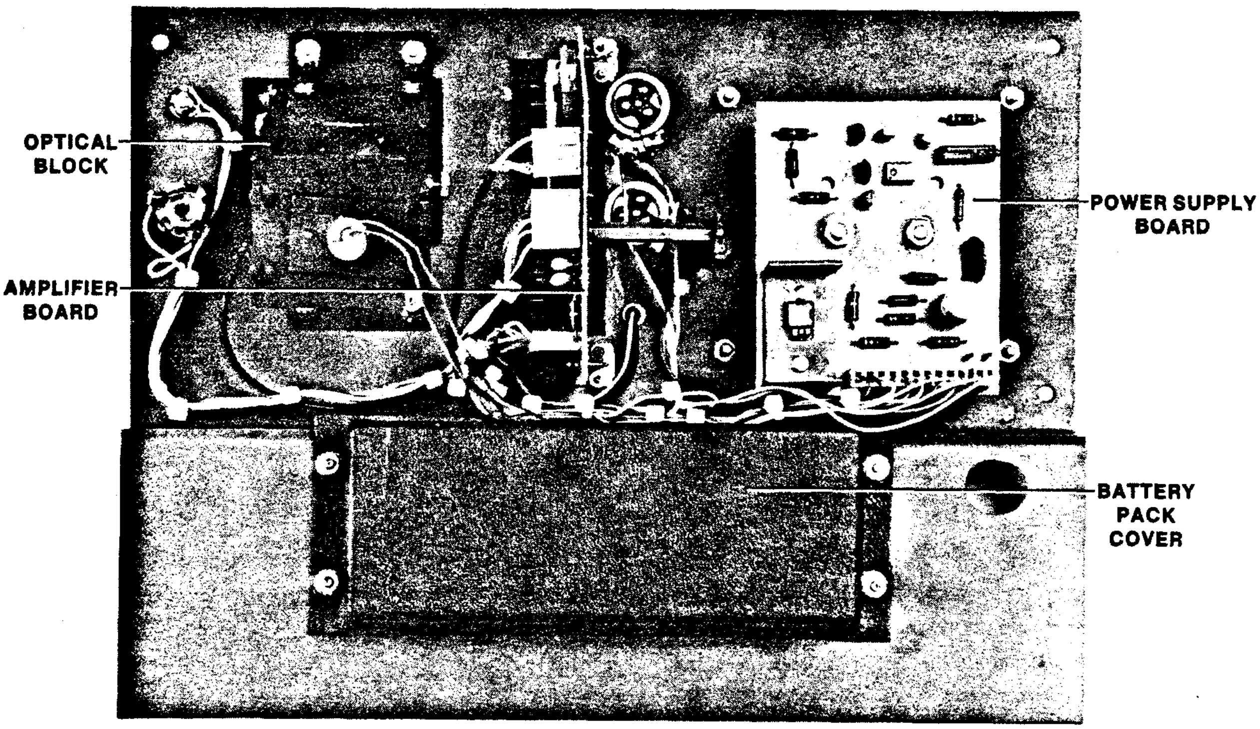


FIGURE 7 **CONTROL PANEL, REAR VIEW**

2. Lift the panel from the case and place it face up on a protective mat.
3. Unplug the lamp connector from the power supply circuit board. *See Figure 7.*
4. Remove the two lamp adjusting screws. The lamp and lamp holder are a single assembly and must be replaced as a unit.
5. Install the new lamp assembly and plug in the lamp connector.
6. Check the lamp position and focus using the focusing template *as described in the Lamp Alignment and Focusing procedure.*
7. Reinstall the panel in the instrument case and restandardize the instrument.

Photocell Replacement

1. Remove the two screws and washers in the cell holder cover and lift off the cover. *See Figure 8.*
2. Unsolder the two coaxial cable connections from the photocell circuit board.
3. Remove the four screws and washers that secure the photocell circuit board to the side of the cell holder. Remove the photocell circuit board assembly.
4. Install the replacement photocell circuit board assembly on the cell holder and solder the coaxial cable leads to the terminals. Note that one of the terminals is marked for the shield connection.
5. Replace the cell holder cover and restandardize the instrument.

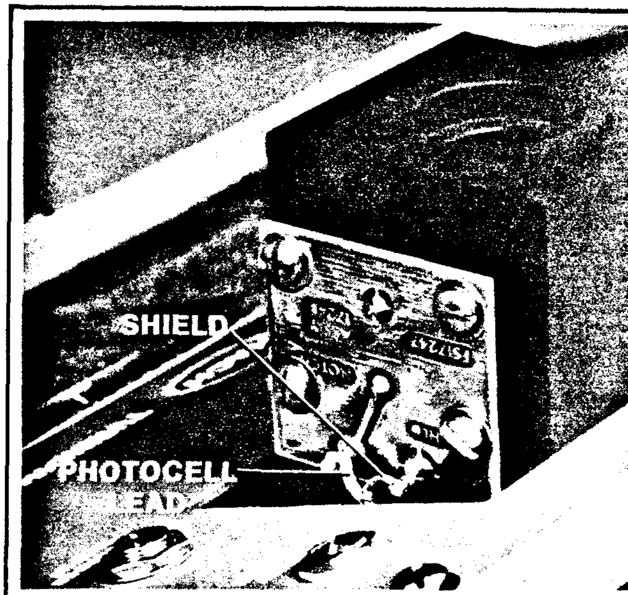
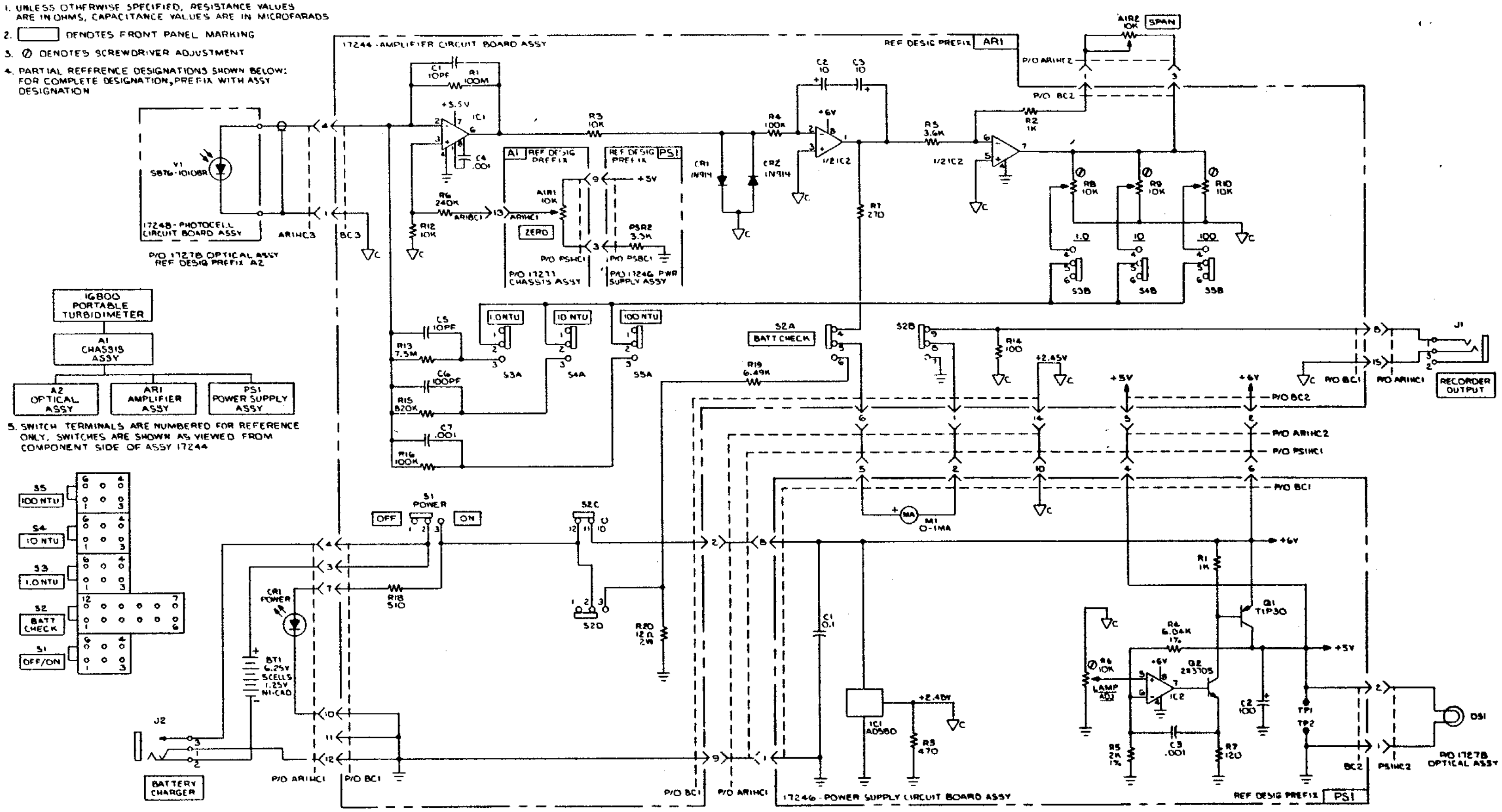


FIGURE 8 PHOTOCELL CONNECTIONS

NOTES-

1. UNLESS OTHERWISE SPECIFIED, RESISTANCE VALUES ARE IN OHMS, CAPACITANCE VALUES ARE IN MICROFARADS
2. [ ] DENOTES FRONT PANEL MARKING
3. Ø DENOTES SCREWDRIVER ADJUSTMENT
4. PARTIAL REFFRENCE DESIGNATIONS SHOWN BELOW: FOR COMPLETE DESIGNATION, PREFIX WITH ASSY DESIGNATION



5. SWITCH TERMINALS ARE NUMBERED FOR REFERENCE ONLY. SWITCHES ARE SHOWN AS VIEWED FROM COMPONENT SIDE OF ASSY 17244
6. COMMON CONNECTION CIRCUIT RETURN IS AS FOLLOWS:
   DENOTES 6.25V BATTERY RETURN
   DENOTES SIGNAL GROUND
7. VOLTAGES MEASURED WITH RESPECT TO
8. ALL SWITCHES SHOWN IN THE UNACTUATED POSITION.

FIGURE 9 **SCHEMATIC**

REPLACEMENT PARTS AND ACCESSORIES

Ref	Description	Cat. No.
	Battery Charger, 115V, 60 Hz/230 V, 50-60 Hz	17058-00
BT1	Battery Pack	16968-00
	Beaker, poly, 50 ml	1080-41
	Bottle, wash, 4 oz	620-14
	Case, Portalab Turbidimeter	17276-00
	Cell Riser	17241-00
AR1	Circuit Board, amplifier	17244-00
PS1	Circuit Board, power supply	17246-00
	Foam Insert, case	17282-00
	Focusing Template	17295-00
	Instruction Manual	40298-00
DS1	Lamp Assembly	17238-00
	Lens Assembly	17281-00
	Light Shield	17239-00
M1	Meter, with scale	17292-00
V1	Photocell Circuit Board Assembly	17248-00
	Plug, recorder input, 3-conductor	16084-00
R1, R2	Potentiometer, 10 turn, 10K (span and zero adj)	12365-18
	Silicone Oil, ½-oz SCDB	1269-36
	Standardization Kit	22958-00
	Stray Light Standard	40263-04
	Turbidity Standard, 90 NTU	22957-03
	Turbidity Standard, 9 NTU	22957-02
	Turbidity Standard, 0.9 NTU	22957-01

OPTIONAL ACCESSORIES AND APPARATUS

Digital Titrator	16900-01
Filters, membrane, 0.45 micron	13530-00
Filter Holder	13529-00
Filter Pump	2131-00
Flask, filtering, 1000 ml	546-53
Flask, volumetric, class A, 50 ml	14574-41
Flask, volumetric, class A, 500 ml	14574-49
Sample Cell Kit, set of 4	21002-00
Stopper, filter flask, no. 7, pkg of 6	2119-07
Tubing, rubber	560-19
Tweezers, plastic	14282-00

OPTIONAL REAGENTS

Formazin Cartridge, Digital Titrator, 4000 NTU	2461-01
Formazin Stock Solution, pint, 4000 NTU	2461-11
Hexamethylaminetetramine, 500 g	1878-34
Hydrazine Sulfate, 100 g	742-26
Triton X-100 Solution, 4-oz DB	14096-13

REPAIR SERVICE

If you wish to return the instrument for factory service, please write or call the nearest Hach Factory Service Center first for shipping instructions. Without prior arrangement, charges for "Collect" shipments are customarily rebilled to the customer.

FACTORY SERVICE CENTERS

Hach Company
100 Dayton Ave.
P.O. Box 907
Ames, IA 50010
(515) 232-2533

Hach Company
57th St., Lindbergh Pkwy.
P.O. Box 389
Loveland, CO 80539
(303) 669-3050

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13003 Southwest Freeway
Suite 150
Stafford, TX 77477
(713) 240-8066

Hach Company
7854 Browning Road
Pennsauken, NJ 08109
(609) 662-0034

Hach Company
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Fremont, CA 94538
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Hach Company
2046-I West Park Place
Stone Mountain, GA 30087
(404) 498-0511

Hach Company
1901 Production Road
Fort Wayne, IN 46808
(219) 482-3015

If you are located in Canada, Latin America, the Caribbean, the Far East or the Pacific Basin, please contact Hach Company, World Headquarters, P.O. Box 389, Loveland, Colorado U.S.A. 80539. Telephone (303) 669-3050, TWX (Telex) 910-930-9038. Customers located in Europe, the Middle East or Near East, or in Africa, please contact Hach Europe, S.A./N.V., B.P. 51, 5000 Namur 1, Belgium. Telephone (081) 44.53.81, Telex 846-59027.

WARRANTY

Seller warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

The liability of Seller under this warranty is limited, at Seller's option, solely to (1) repair, (2) replacement with equivalent Hach equipment, or (3) an appropriate credit adjustment not to exceed the original sales price of equipment returned to the Seller, provided that:

a. Buyer promptly notifies Seller in writing on discovery of the defects, stating where applicable, the product type and serial numbers and fully describing the circumstances giving rise to the claim. Seller must receive such notification within the applicable warranty period in order for this warranty to apply.

b. On receipt of written instructions from Seller, Buyer returns the equipment as instructed with transportation charges prepaid by the Buyer; and

c. Seller's examination of such equipment discloses to its satisfaction that the defects have not resulted from any negligence, misuse, improper installation, accident or unauthorized repair or alteration by the Buyer. Seller's determination of the cause and nature of the failure of the equipment shall be final.

This warranty does not include limited life electrical components which deteriorate with age such as vacuum tubes, batteries, lamps, photocells, electrodes, etc. In the case of equipment and accessories not manufactured by the Seller, but furnished with equipment of Seller's manufacture, Seller's liability is limited to whatever warranty is extended by the manufacturers thereof and transferable to the Buyer.

This warranty is applicable to the original Buyer only and shall be in lieu of and exclude all other warranties, expressed or implied, including, but not limited to, any implied warranty of merchantability or fitness. The foregoing shall constitute the sole and exclusive remedy of Buyer and the sole and exclusive liability of Seller, whether Buyer's claims shall be for breach of warranty or negligence. Seller neither assumes nor authorizes any person to assume for it any other obligation or liability in connection with the sale of the equipment. In no event shall Seller be liable for special, incidental, or consequential damages.

If Seller finds that Buyer has returned the equipment without cause, Seller shall notify Buyer and return the equipment at Buyer's expense; in addition, Seller may, at its sole discretion, impose a charge for testing and examination of any equipment so returned.

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HACH COMPANY
P.O. Box 389, Loveland, Colorado 80539 U.S.A.
303-669-3050 TWX: 910-930-9038

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